PREM

Personalised Residential Energy Model

A thesis presented in fulfilment of the requirement for the degree

Master of Applied Science

in Natural Resource Engineering

at Massey University, Palmerston North,

New Zealand.

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2004

Abstract

Climate change is a major world environmental problem accepted by these governments who have ratified the Kyoto Protocol which aims to reduce the amount of greenhouse gases (GHG) internationally 5% below the 1990 level during 2008 to 2012. The Protocol needed the ratification of Russia to get into force as the United States and Australia withdrew from the protocol. The New Zealand government ratified the protocol with the negotiated goal to reduce the GHGs back to the level of 1990. The main driver of this study is to help people reducing their personal GHG emissions in order to meet the government's objective of the Kyoto Protocol.

Many people know about climate change and understand they will need to change their lifestyle significantly to reduce their GHG emissions. The how and where to change is often unclear. People need to be incentivised in order to encourage emission reduction. Some GHG-calculators already exist, but mostly without practical personalised suggestions and financial effects. This study aimed to develop a model which targeted responses by individuals based on their lifestyle and interests.

The Personalised Residential Energy Model (PREM) which was developed in this study uses findings of energy related behaviours from existing psychological and technical research to develop an easy to handle and individualised computer model to assess a person's current energy demand. It includes household and travel demand and assesses the general ecological behaviour. Users will be provided with relevant information to assist them to seek practical and economic solutions in order to reduce their personal CO_2 (carbon dioxide) emissions which is the main GHG in the assessed sectors. Starting with the current situation as a baseline, it establishes which behaviours have the highest probability of being undertaken by the person to lower their energy demand. Information about the financial effect and the CO_2 emission reductions are provided for specific activities. Energy efficiency and conservation are the main focus of the model output. Further research could include the possible use of renewable energy.

Using PREM found changes in domestic dwellings and transportation vehicles to be an important factor in reducing anthropogenic CO_2 emissions. The model is made for New Zealand conditions but can be adapted to suit any other country.

Acknowledgements

Central Power Electricity Trust is acknowledged for providing the funding to work one year on this thesis.

Assoc. Prof. Ralph Sims, who was my main supervisor, gave me the opportunity to start a thesis with him in the Centre for Energy Research and organised the funding, contacts and much more. He supported me with his broad experience and clear view which was invaluable. Thanks for your great support.

Dr. Patrick Dulin was my co-supervisor for the psychological field. It was extremely valuable to have his support since psychology was a new subject for me. Thanks for the patience and the time to lead me on the way to find the right approach to the environmental psychology.

Assoc. Prof. Florian Kaiser was very helpful by discussing the GEB-scale (General Ecological Behaviour), which he developed to measure people's environmental behaviour.

Many thanks to all who supported the thesis with the English correction: Andrew Smith, Simon Bernt, Paul Milsom and Danielle Poulos.

Finally I would like to acknowledge my parents who supported me in many ways during the entire time of my studies, also from Switzerland when I was in New Zealand. Thanks for trusting in the way I was going. It was a great experience!

Many thanks to all!

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1. Chapter Introduction

Global warming has been a serious issue for more than a decade. Although not a general topic of conversation, many people and businesses have began to realise the potential seriousness of the problem. This is particularly the case when they see the floods, storms and droughts in the news that could have been caused by global warming. Some governments are trying to respond through the Kyoto Protocol to reduce the emission of GHGs (greenhouse gases). This protocol would require signatories to reduce six greenhouse gases[1] during 2008-2012 at least 5% below the level of 1990. A high proportion of human produced greenhouse gases are emitted when energy and resources are used. The lower our energy and resource consumption, the fewer the produced GHG emissions.

Every society, government and industry is composed of individuals. To solve a problem such as global warming the majority of people need to recognise the issue. Factors affecting this recognition are primarily impacts on income and lifestyle and the closed eyes for the advantages. Resource efficiency is an attempt to reduce global warming. Seven good reasons for resource efficiency were outlined by Weizsäcker, Lovins, & Lovins (1997):

- Live better: Resource efficiency improves quality of live.
- Pollute and deplete less
- Make money. Resource efficiency is usually profitable: you don't have to pay now for the resources that aren't being turned into pollutants, and don't have to pay later to clean them up.
- Harness markets and enlist business
- Multiply use of scarce capital
- Increase security. Competition for resources causes or worsens international conflicts.
- Be equitable and have more employment

This research study shows how the actual personal energy consumption of a person can be identified, measured and a way found, adjusted to the individual user, to be resource efficient by reducing energy demand and CO_2 emissions.

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[1] Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Perfluorcarbons (PFCs), Hydrofluorcarbons (HFCs) and Sulphur Hexafluride (SF_6)

1.1. Objectives

The general aim of this study was to determine the extent to which individual decisions and behaviour contribute to energy consumption, greenhouse gas emissions and cost savings. The thesis aimed to include environmental psychology into a technical based energy model to make it more individualised and subsequently, with the aid of psychological instruments, to determine how a specific person is most likely to change his or her behaviour to reduce GHG-emissions. The specific objectives of this study were to:

- develop a model implemented as a computer program to assess a person's household and transport energy usage, which will be shown in the form of a monthly bill;
- identify psychological methods to make behavioural changes more likely; and
- to add CO_2-emissions and \$ values to certain behaviours which have environmental impacts.

Psychological research showed behaviour change is more likely if information is personalised, vivid and specific (Stern, 1992). "People typically over estimate energy use for lights and appliances that are visible and that must be actuated for each use, and they under estimate energy use for water heating or other less visible ends." This is where the connection between psychology and technical energy solutions become important. Using both psychological knowledge and the technical options, this model shows its users where, how and how much energy and hence CO_2 and money can be saved.

The entity assessment of the developed model in this study (Fig. 1) includes the energy use and CO_2 emissions from car models, public transport types and domestic dwellings, in order to identify the energy usage of each service with resulting costs and CO_2 emissions. The analysis of this information was used to calculate the monthly energy cost and emission bill adjusted to the specific person whereby emission will be shown as a dollar value too in order to make it more understandable.

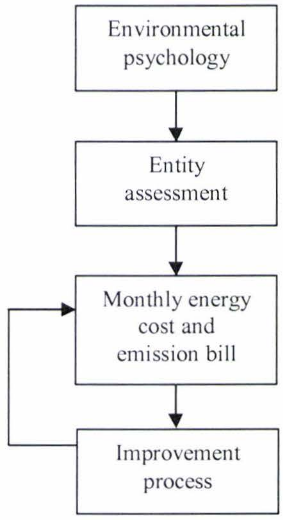

Figure 1: Personalised Residential Energy Model (PREM)

The model[2] allows the user to interact in an easy and slightly guided way as the improvement process (Fig. 1). All changes the user makes will immediately change the energy flows and the emissions. As a result the monthly bill will be adjusted. The model aims to find solutions to improve energy use and resource efficiency for the specific user based on the information provided.

[2] "The model" is always used to refer to the developed model in this study

1.2. Scope

Energy is used in every activity. This study will cover the energy use of a person's residential and transportation sector (Fig. 2). In this section a high proportion of a person's total consumption will be covered. The reason of this choice is, in ones own household and private transportation, the particular person is able to make decisions if desired and to change behaviour. It is also believed, if people see the pros of resource efficiency and its cost savings on their own, cost balance will then lead to more understanding and activities in industrial, agriculture and governmental based resource efficiency improvements.

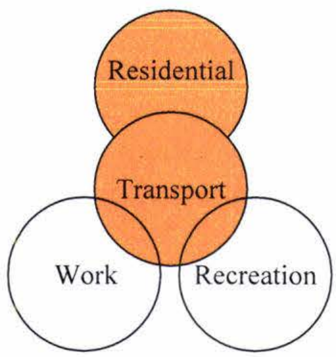

Figure 2: The parts of a person's life subdivided by basic activities. The living and transportation parts are covered in this study.

People use energy with every activity in various forms. To develop a computer model in a Masters thesis with a timeline of a year the study needs to focus. The chosen scope was domestic transport and household energy usage including the utilisation stage of the dwellings.

The residential component contains household energy use with required heating, hot water and other associated dwellings. Topics not included in the study were consumerism (such as buying food and clothes), house construction (embodied and construction energy) and waste treatment from all these services. The transport sector included both individual and public transport for all main travel types (bike, car, plane, train and bus). The work sector was excluded due to the shared responsibility of the employer and employee. However the individual can also make a difference also at their work place. In our society recreation is valued largely and the associated energy use is not expected to be small as a great number can afford hobbies such as riding a motor bike, motor boating, skiing, snowboarding or enjoying a day in an artificially heated pool. The recreation sector was only excluded due to time constraint.

Every technical device contains "embodied energy" as all of them have a life cycle which includes the development, realisation, utilisation and the final stage of disposal (Fig. 3). Each stage needs energy input and has GHG emissions as an output. To fully compare devices most accurately would be to take all four stages into account which requires a life cycle analysis (LCA). This study will concentrate mainly on the utilisation stage after the device is purchased and when it relies on direct energy inputs to provide the desired service.

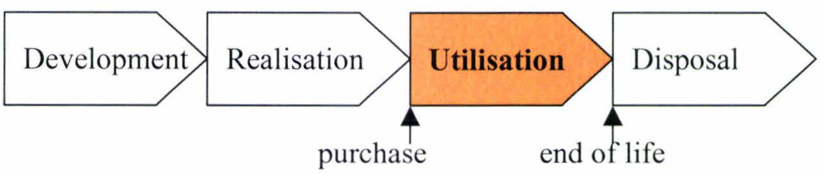

Figure 3: The four stages of a device lifecycle. This study takes only the utilisation stage into account.

1.3. Context

- Chapter 2 sets the scene with the literature review which explains the climate change science, national and international conventions and projects to tackle anthropogenic climate change, the costs caused by natural disasters and what other software in this field was produced.

- Chapter 3 explains the design of the model PREM.

- Chapter 4 shows general findings of environmental psychology and the approach used in this study.

- Chapter 5 provides information on the model's calculations and the data source used to develop the model.

- Chapter 6 describes how the developed model, was verified by using two different types of energy users. Mr. Greeny's and Mr. Carless energy usage were assessed and compared.

- Chapter 7 shows where further research could take place and concludes the thesis, by showing how the objectives were met.