TAMPEREEN TEKNILLINEN YLIOPISTO
TAMPERE UNIVERSITY OF TECHNOLOGY

Aija Tapaninen

Adoption of Innovation:
Wood Pellet Heating System in the Renewable Residential Energy Context

Julkaisu 884 • Publication 884

Tampere 2010

Tampereen teknillinen yliopisto. Julkaisu 884
Tampere University of Technology. Publication 884

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Thesis for the degree of Doctor of Technology to be presented with due permission for public examination and criticism in Tietotalo Building, Auditorium TB222, at Tampere University of Technology, on the 28th of May 2010, at 12 noon.

Tampereen teknillinen yliopisto - Tampere University of Technology
Tampere 2010

ISBN 978-952-15-2357-1 (printed)
ISBN 978-952-15-2484-4 (PDF)
ISSN 1459-2045

ABSTRACT

Tapaninen, Aija. 2010. *"Adoption of Innovation: Wood Pellet Heating System in the Renewable Residential Energy Context."* Faculty of Business and Technology Management. Tampere University of Technology, Tampere, Finland.

Keywords: Adoption; attribute; characteristics of innovation; wood pellet heating; survey

Getting a new idea widely adopted is difficult. For companies, therefore, it is fundamental that customers are willing to adopt the provided idea or a technological system. Understanding customers, their perceptions, and the attributes influencing the decision to adopt is essential. Thus, this research focused on customers of residential heating, particularly wood pellet heating systems. Accordingly, this research dissects the adoption of innovation in a renewable residential heating energy context, particularly what influences the decision to adopt the wood pellet heating system.

A vast amount of literature on the adoption of innovation was reviewed from the innovation and customer perspectives. To gain information about customers and their perceptions, a survey (N=154) was conducted in 2007. Both quantitative and qualitative methods were used in analyzing the results; in particular, the content analysis method was utilized.

The research results showed that personal attributes influence issues related to the adoption of wood pellet heating systems. In particular, first, men had more perceived familiarity and knowledge than women regarding issues related to the adoption of wood pellet heating systems. Second, age influenced the intention to select a new heating system; the intention to do so was greater in respondents aged 35-44 compared to those aged 25-34. Furthermore, the research demonstrated that information related to wood pellet and related technologies is communicated in several kinds of publications and that communication increased during the observation period, especially during the 21st century.

In addition, the perceived acquisition factors, i.e., barriers and criteria, of the wood pellet heating system influencing the decision to adopt the system were examined. The factors were primarily categorized according to Rogers' characteristics of innovation. The categorization showed differences between characteristics of innovation influencing the decision to adopt a wood pellet heating system. In particular, the results demonstrated that relative advantage was the predominant characteristic influencing the decision to adopt these particular heating systems. The combination of theoretical perspectives on the innovation characteristics and the value for customers indicated that perceptions and adoption decision factors interlock with the value for customers.

In conclusion, this research explored attributes influencing the decision to adopt wood pellet heating systems. The research contributes to the adoption of innovation literature by providing multiple findings analyzed by several theories in the context of renewable residential heating systems. Thus, this research can be considered further improvement in the management of innovation and technology research field. Suggestions are provided for managerial practices, energy policy, and future research. Ultimately, this research will guide further research to increase our knowledge.

ACKNOWLEDGEMENTS –Making dreams come true!

Joint trips are much more fun than travelling alone. The journey from a student at Tampere University of Technology (TUT) to a Doctor of Technology has taken me about two and half years. During this time I have come to learn much about research and researching. I retain many fond memories from this journey and I have met many wonderful people whom I now wish to thank for their support and encouragement in helping me to reach my goal.

The starting point of this research was my master's thesis. Here I would like to express my gratitude to my colleagues and collaborators, Ilkka Uusi-Maahi, Johanna and Hannu Teiskonen, Timo Korpela and Pentti Nyrhinen and also all those who participated in the project.

On gaining my Master of Science in Engineering, I eagerly took up the opportunity of full-time research in the Department of Industrial Management. This was made possible thanks to the help and encouragement of my Professor, Saku Mäkinen, to whom I am greatly indebted. I am also grateful to the members of the Department of Industrial Management, Finnish Doctoral Program in Industrial Engineering and Management and TEKES as well as those other companies for their generosity in financing the research.

The job of researcher entails making new contributions to enlarge our world of knowledge. However the path to greater knowledge is not always straight forward and sometimes one can lose one's direction. An experienced guide can be vital for survival! My guide along this path has been my supervisor, Marko Seppänen, Ph.D. whose support and guidance have been critical in keeping my research on course. Thank you, Marko!

I have the honor of being a member in CITER (Center for Innovation and Technology Research) whose objective is to increase the understanding of co-evolution of innovations and of technologies in a society at large. My bold and beautiful colleagues in CITER have taught me much about life as a researcher. In particular, I would like to thank my friends and colleagues Heini Järvenpää and Ozgur Dedehayir for their company and support on my journey through the world of research. Thanks are also due to Hanna-Kaisa Desavelle, Henri Suur-Inkeroinen and Tomi Nokelainen, Ph.D. for all those inspiring conversations aimed at making the world a better place. Thanks also go to our present and former team members! I would like to express my thanks to the personnel of TUT, especially Sirpa Järvenpää, Jukka Annala, Juho Kanniainen, Ph.D., Santeri Repo and Alan Thompson for all their help and kindness. I also owe a debt of gratitude to all those other people who have helped me in this endeavor. Thank You!

In addition, I am profoundly grateful to Professor Roland Ortt and Professor Tuomo Kässi for agreeing to review my research for this dissertation. Thank you both for your valuable and constructive comments during the research process!

Of course, there is more to life than only toil and research. I am, therefore, deeply indebted to my beloved family, friends and relatives! Mom Pirjo, Dad Jorma, big brother Asmo and friend Tuula, even though you may be far away, you are forever in my thoughts. Finally, my heartfelt thanks go to you, Heikki, my nearest and dearest. May I share with you the joy of seeing my life's dream made real? Thank you!

ALKUSANAT –Unelmamatkat ovat toteuttamista varten!

Muiden kanssa matkaaminen on mukavampaa. Matkani Tampereen teknillisen yliopiston (TTY) diplomi-insinööristä tekniikan tohtoriksi kesti noin 2,5 vuotta. Sinä aikana opin tutkimuksen tekemisestä ja tutkijana olemisesta, keräsin kasvattavia kokemuksia ympäri maailmaa ja ennen kaikkea sain olla tekemisissä ihanien ihmisten kanssa, joita haluan kiittää seuraavaksi tämän väitöskirjan toteutumisesta.

Väitöskirjani lähtökohdat ovat tekemässäni diplomityössä, josta kiitos kuuluu Ilkka Uusi-Maahille, Johanna ja Hannu Teiskoselle, Timo Korpelalle sekä Pentti Nyrhiselle sekä muille diplomityöhöni osallistuneille henkilöille.

Siirtyminen vastavalmistuneena tuotantotalouden diplomi-insinöörinä tutkijaksi ja jatko-opiskelijaksi teollisuustalouden laitokselle ei olisi ollut mahdollista ilman arvoisaa laitosjohtajaa. Siis, suuri kiitos professori Saku Mäkinen asioiden tekemisestä mahdolliseksi! Kiitos tutkimukseni rahoittamisesta kuuluu TTY:n teollisuustalouden laitokselle ja Tuotantotalouden tohtorikoulusäätiölle sekä TEKES:lle ja muille projektien rahoitukseen osallistuneille.

Tutkijan työ on uusien asioiden löytämistä pitkälti aikaisemman tiedon pohjalta. Joskus tutkimus tuntuu polkevan paikallaan, joskus sitä löytää itsensä takaisin lähtöpisteestä. Matkalla hyvä opas on tarpeen. Oppaani, ohjaajani, TkT Marko Seppänen on ollut merkittävä väitöskirjaani vaikuttaja. Ilman yhteistyötämme, hänen ohjeistustaan ja kärsivällisyyttään vastata pieniin ja suuriin kysymyksiini, tätä väitöskirjaa ei olisi. Kiitos Marko!

Olen osa teknologista kehitystä ja innovaatioita tutkivaa tutkimustiimiä nimeltä Center for Innovation and Technology Research (CITER), jonka fiksut ja filmaattiset kollegani ovat opettaneet minulle tutkijana olemisen taitoja. Kiitos Heini Järvenpää ja Ozgur Dedehayir yhteisistä hetkistämme, erityisesti konferenssimatkoillamme! Kiitos Hanna-Kaisa Desavelle, Henri Suur-Inkeroinen ja TkT Tomi Nokelainen maailmaa parantavista keskusteluistamme! Kiitos myös muut entiset ja nykyiset tiimiläisemme! Kiitos TTY:n henkilökunta, Sirpa Järvenpää, Jukka Annala, TkT Juho Kanniainen, Santeri Repo ja Alan Thompson suurista ja pienistä palveluksistanne! Kiitos kuuluu jokaiselle, jonka olen kohdannut tätä väitöskirjatutkimustani tehdessäni! Kiitos Sinulle!

Lisäksi olen erittäin kiitollinen väitöskirjatutkimukseni tarkastajille, suuri kiitos professori Roland Ortt ja professori Tuomo Kässi! Kiitos arvokkaista ja rakentavista kommenteistanne!

Vaikka aivot analysoisivat jatkuvasti, elämä on muutakin kuin työtä. Sydämellinen kiitos rakas perheeni, sukulaiseni ja ystäväni! Äiti, isä, veljeni Asmo ja ystäväni Tuula, vaikka olette kaukana, olette lähellä sydäntäni. Lopuksi, haluan kiittää rakasta avomiestäni, Heikkiä, jokaisesta hetkestä, jonka saan jakaa kanssasi tällä elämäni matkalla. Kiitos!

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PART TWO: ORIGINAL ARTICLES

1. Tapaninen, A. (2008) Do Customers' Personal Attributes Matter in the Adoption of Wood Pellet Heating? *Proceedings of the IEEE International Engineering Management Conference (IEMC). Estoril, Portugal, June 28-30*.

2. Tapaninen, A. & Seppänen, M. (2009) Assessing the Development Phase of Emerging Technology: The Wood Pellets Case. *Proceedings of IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), Hong Kong, December 8-11*.

3. Tapaninen, A., Seppänen, M., & Mäkinen, S. (2009) Characteristics of innovation: a customer-centric view of barriers to the adoption of a renewable energy system. *Int. J. Agile Systems and Management.* 4(½): 98-113.

4. Tapaninen, A., Seppänen, M., & Mäkinen, S. (2009) Characteristics of innovation in adopting a renewable residential energy system. *Journal of Systems and Information Technology*. 11(4): 347-366.

5. Tapaninen, A. & Seppänen, M. (2009) Characteristics of Value in Green Technology Investments. *Proceedings of Portland International Conference on Management of Engineering & Technology (PICMET), Portland, USA, August 2-6.*

The author's contribution to the original joint articles is as follows.

In the 1st article, Tapaninen is the sole author.

In the 2nd article, Tapaninen is the lead author. Tapaninen collected the empirical data. In addition, Tapaninen was the main designer and writer of the article. A previous version of the 2nd article was published in the proceedings of The 4th IEEE International Conference on Management of Innovation & Technology (ICMIT), September 21-24, 2008, Bangkok, Thailand.

In the 3rd article, Tapaninen is the lead author. A previous version of this article was published in the proceedings of the Third European Conference on Management of Technology (EuroMOT2008), September, 17-19, 2008, Nice, France, in which Tapaninen was the sole author. Collaboration for the 3rd publication was an interactive process. In addition, Tapaninen was the main designer and writer of the article.

In the 4th article, Tapaninen is the lead author. A previous version of the 4th article was published in the proceedings of the conference of the International Association for Management of Technology (IAMOT2009), April 5-9, 2009, Orlando, Florida, USA. Tapaninen was the main designer and writer of the article. In addition, Tapaninen collected the empirical data. Collaboration for the 4th publication was an interactive process, in which Tapaninen had the leading role among the authors.

In the 5th article, Tapaninen is the lead author. Tapaninen was the main designer, analyst, and writer of the article.

PART ONE: OVERVIEW OF THE DISSERTATION

1. INTRODUCTION

This thesis includes two parts. The first part is the overview of the dissertation, research that introduces and combines the essential parts of the studies that were published in five peer-reviewed articles. The second part includes the original articles.

1.1. Motivation and structure

Innovations are diffused after the decisions to adopt innovations are completed. However, getting a new idea, even with significant advantages, is difficult and might require several years to become widely adopted (Rogers 2003: 1). Moreover, for many innovations, coming to the mass markets is challenging (Moore 1999; Statt 1997: 25). For companies, therefore, it is fundamental that customers are willing to adopt an innovative idea or a technology that the companies provide. Therefore, understanding customers, their perceptions, and the attributes influencing the decision to adopt is essential.

According to Rogers (2003), between 49% and 87% of the variance in adoption can be explained in terms of five attributes: relative advantage, compatibility, complexity, trialability, and observability. However, while there is rather general agreement regarding relevant factors, there is little consensus on the relative importance of the different factors. In addition, many researchers claim that perceived value for the customer has a motivating impact upon willingness to buy (Dodds, Monroe, & Grewal 1991; Sweeney, Soutar, & Johnson 1999; Zeithaml 1988; Treacy & Wiersema 1993). The use of customers' perceptions in the adoption of innovation is based on the assumption that perceptions of customers directly impact intentions; these, in turn, impact behavior (Bolton & Drew 1991).

Furthermore, adopters of innovation differ from each other (Dickerson & Gentry 1983; Mahajan, Muller, & Srivastava 1990). Customers could be categorized based on their differences. However, some customers may decide not to adopt the innovation at all (Dickerson & Gentry 1983). Hence, profiling customers might save costs in developing and promoting the idea with a targeted method for attracting potential customers.

The vast literature on the adoption of innovation highlights the use of adoption attributes. Thus, despite the noticeable prior work on the adoption of innovations in a residential heating context (Mahapatra & Gustavsson, 2008a, 2008b, 2009), there is a lack of academic literature on the attributes influencing the decision to adopt wood pellet heating systems.

Hence, the question, what influences the adoption of innovation, is of practical and academic concern. Accordingly, this research dissects what influences the decision to adopt a renewable residential heating energy system. Thus, the objective of this research is to study the adoption of an innovation in a renewable residential heating energy context, particularly in terms of what influences the decision to adopt the wood pellet heating system. A wood pellet heating system is one option for heating residential houses with renewable energy. Such options are innovated in order to respond to the increased need for renewable energy and in combating climate change.

The structure of the research is as follows. Initially in the research, the contextual background of the research is described. Second, the research questions and objectives set up the focus of the research. Third, the settings of the research include a discussion of the general outline of the research and research design and methods. In the review of the literature on adoption of innovation, previous research is first reviewed from an innovation perspective, including the diffusion of innovation, the innovation decision process, and the characteristics of innovation; second, previous research is discussed from the customer's perspective, including adopter categories and value for customer. In the second chapter, summaries and findings of the articles, i.e., five peer-reviewed and published articles, are described. In the conclusions, after the contribution of the research and discussion sections, an assessment of the research, including reliability and validity, is given. Finally, suggestions for managerial practice, energy policy, and future research are presented.

1.2. Contextual background of the research

Forestry is one of the growing clusters of biomass and bio-fuels as sustainable and renewable energy literature (Kajikawa & Takeda 2008). Recent studies have investigated, for instance, the potential of bioenergy production and forest energy business (Rikkonen 2009; Pätäri 2009). In addition, wood pellets as a renewable energy source have received a fair amount of attention (Järvenpää & Tapaninen 2008).

This section describes the political targets and renewable energy, particularly wood pellets and wood pellet heating. The context is first reported from the global perspective and, second, from the Finnish perspective. The description gives an outline of the contextual background of the wood pellet heating system.

1.2.1. Global perspective

The Worldwatch Institute's State of the World (The Worldwatch Institute 2009) report raised the following questions: How will climate catastrophe play out in this century? What are the urgent actions that should be taken? Furthermore, the European Commission (EC) has announced several ambitious proposals to cut emissions of greenhouse gases and boost the use of renewable energy (Barroso 2008; EC 2008). According to these proposals, the share of renewable energy will reach 20% in all member states, and the market share of bio-fuels will exceed 10% by the 2020. Thus, limiting climate change and the increasing need for energy are major driving forces in the development of innovative technologies for more sustainable energy production.

However, although the European Union (EU) has enormous biomass resources and expertise in relation to alternative technologies, the EU still faces challenges in accelerating the adoption of bio-energy systems. Economic conditions, expertise, and institutional capacity, as well as supply chain co-ordination, are key barriers to the propagation of bio-energy in Europe (McCormick & Kåberger 2007).

Wood biomass is a renewable recourse that is considered greenhouse gas (GHG) neutral when heat energy is converted properly (Chau et al. 2009). In addition to traditional methods of burning wood as fuel, several new technologies have been developed to increase the use of renewable energy.

Renewable energy is used to produce electricity and, in the heating energy context, to produce hot and warm water and steam.

Wood pellets are one option for renewable energy in the residential heating context. Wood pellets are small, cylindrical, compressed chips of wood burnt in stoves and boilers (Lappalainen 2007; Fiedler 2004; Vapo 2004), and are used mainly in domestic heating. Wood pellets are produced at high pressure by extruding ground wood through a mechanical die (Polagye et al. 2007). A densification process of wood pellets consists of three unit operations: drying, size reduction (grinding), and densification (pelletizing). After wet sawdust is dried in a rotary drier, a hammer mill is used to reduce the biomass to a particle size suitable for pelleting. The dry ground biomass is finally compacted in the mill to form pellets. Due to the frictional heat generated during extrusion and material pre-heating, when wood pellets come out of the pelleting machine, they are usually very hot (70-90 °C). To harden and stabilize the pellets, they are cooled. (Magelli et al. 2009) Wood pellets are more expensive than wood residue, since they require extra fabrication processes and transportation (Chau et al. 2009). The overall wood pellet heating system, for instance, for heating single-family houses, typically consists of a boiler or stove, burner, chimney, wood pellet transport system, and storage facility. The wood pellets are transported from storage, using methods such as conveyor screws or suction systems, to a boiler inside the stove. (Fiedler 2004) System refers here to a set of interrelated units that are engaged to accomplish a common goal. Thus, heating the house could be seen as the goal of the wood pellet heating system. Wood pellet technology for residential use is a bio-energy-based heating system (Lappalainen 2007; Fiedler 2004; Heinimö 2008).

However, there have also been some adverse reports on environmental issues and emissions associated with the use of wood pellets, and some critical views have been presented. A few of these topics concern emissions, slagging, the effects of fuel combustion, and burner efficiency (Vinterbäck 2004). Such issues provide topics for future management and engineering research to make wood pellets more attractive and environmentally friendly.

Although wood pellets have been produced since the late 1970s, starting in North America (Vinterbäck 2004), wood pellet technology for residential use is a rather new bio-energy-based heating system (Lappalainen 2007; Fiedler 2004); thus, wood pellet burning technology could be considered an innovative technology in heating systems.

The adoption rates of wood pellet heating systems vary widely across European countries (Fiedler 2004). The EC (2008) has contributed to the spread of wood pellet technology in the global awareness of bio-energy technologies. In Europe, the forerunners of wood pellets use have been Austria, Sweden, and Denmark (Vinterbäck 2004). The production and consumption of wood pellets vary in different countries; for instance, Canada, Austria, Germany, Finland, Russia, and Poland produced more wood pellets than they consumed in 2007. Sweden, the United States, Italy, and Denmark consumed more tons/year wood pellets than these countries produced (Tuohiniitty 2010a), providing a global market for wood pellets. Sweden has been rather large wood pellet market in the consumption and production of wood pellets (Aebiom 2007; Tuohiniitty 2010b).

The difference between European countries is discussed to indicate the importance of active energy politics and the taxation of fossil energy in encouraging development (Aebiom 2007). In Sweden and Denmark, taxation of fossil fuels and subsidies for biomass have made exporting wood pellets

economical (Alakangas et al. 2009). Hence, despite the forestry potential, Finland has scant use for wood pellets for thermal energy production and they are argued to lacking significant economic incentives (Aebiom 2007).

The literature lacks studies of subsidies and tax policies regarding wood pellet heating. The Finnish Wood Pellet Association (Tuohiniitty 2010) reports some public subsidies for adopting wood pellets and wood pellet heating systems in European countries such as Sweden, Norway, Austria, Germany, France, Great Britain, and Finland. All these countries provide subsidies for investments. The taxation of other energy sources influences the adoption of the heating system, especially in Sweden and Austria. Sweden and Finland provide reductions in housekeeping taxes. In addition, subsidies for producing renewable energy are provided in Sweden and Germany. (Tuohiniitty 2010) Notwithstanding, Sweden has a wide variation in public subsidies for adopting wood pellet heating systems compared to other European countries. Subsidies for investments are provided for work, material, or system investments. The investment subsidy can be also in the form of a tax reduction. (Tuohiniitty 2010a) The taxation and subsidies can be sensitive to local differences and changes in time. In addition, the subsidies taxation can be direct or indirect in the residential heating context.

Varied subsidies and promotion have also been reported in increasing the use of wood pellets. As examples of national support, France has a finance law from 2005 for sustainable development, which aims to lower biofuel costs, subsidies for biofuel conversion systems, and high efficiency of technical systems. In Germany, there is the Programme to Promote Renewable Energies, which supports biomass heating systems and in which small-scale wood pellet heating systems are granted. The Swedish energy taxation policy encourages the use of biofuels. (Aebiom 2007) Hence, the subsidies and policies vary in different countries. However, the policies are stated to have an influence on the rate of adoption of the wood pellet heating system (Aebiom 2007). Sweden, interestingly, is remarkable both in producing and consuming wood pellets and has several public subsidies for the adoption of wood pellet heating.

The wood pellet heating system is a substitute for other heating systems, and therefore faces competition. Typical of the factors influencing the competition between wood pellets and other sources of bio-heating energy are investment costs, fuel price development, taxation, and current interest rates and subsidies (Mahapatra & Gustavsson 2008b; Lappalainen 2007; Madlener 2007; Ericsson et al. 2004). Homeowners assess the heating system–related factors in Sweden with respect to annual cost of heating, investment cost, functional reliability, indoor air quality, security in fuel supply, system automation, environmental friendliness of the system, increases in the market value of the house, low GHG emissions, and time required to collect information (Mahapatra & Gustavsson 2009, 2008b). Furthermore, Mahapatra and Gustavsson (2009) found a change in customers' perceptions in the resurvey. Environmental benignity, indoor air quality, system automation, low GHG emission, and market value were perceived to have significantly higher importance compared to the baseline survey. Interestingly, investment cost was perceived as significantly less important in the resurvey, which is explained by investment subsidies in Sweden (Mahapatra & Gustavsson 2009).

1.2.2. Finnish perspective

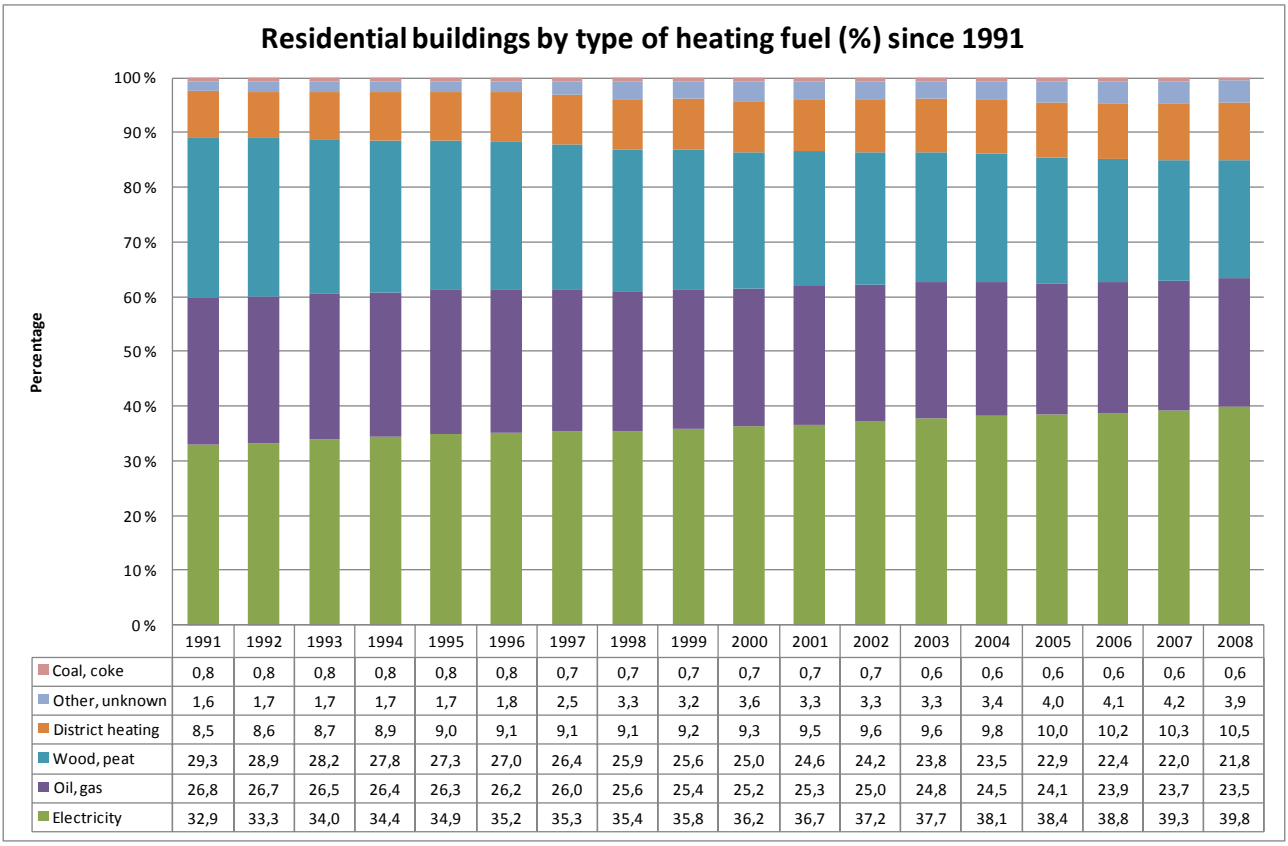
As a member of the European Union, Finland has committed itself to the EU's climate and energy targets. The objective of Finland's national energy and climate strategy is to increase the use of renewable sources of energy and their share of energy consumption (Ministry of Employment and the Economy 2008).

Cold climate and long distances are typical in Finland. Total energy consumption was 1.42 million TJ in 2008 (Statistics Finland 2009a), which consisted of fossil fuels (46%), renewable energy sources (28%), nuclear energy (17%), peat (6%), and others (4%). Wood fuels provide 21.3% of the energy consumption, where 10% comes from black liquor and other concentrated liquors, 7% is wood fuels used in industry and energy production, and 4% small-scale combustion of wood. (Statistics Finland 2010a) Use of renewable energy sources has increased in Finland in the 21st century (Statistics Finland 2009b).

Moreover, Finland is one of the world's leading users of renewable sources of energy, especially bioenergy (Juninger et al. 2008). The biomass fuels (total 292.5 PJ) used in Finland in 2007 was black liquor (154 PJ), solid processing industry by-products and residues (73.5 PJ), forest fuels (21.9 PJ), firewood (44.8 PJ), wood pellets (2.0 PJ), and other biomass fuels in total (Alakangas et al. 2009). Hence, biomass resources in Finland are closely related to the forest industry.

Productive forest land covers 66% of the total land area in Finland (Ericsson et al. 2004). Since the yearly growth of forest biomass is equal to approximately 56 million tons of dry biomass, wood forms the major source of biomass for the Finnish economy (Aittomäki et al. 2007). However, the potential overall energy market is estimated to be larger than the annual availability of biomass (Aittomäki et al. 2007).

The industry, transport, and residential sectors are the most important sectors in total energy consumption. Use of renewable energy sources in Finnish residential heating is estimated to increase to 111.6 PJ in 2020 (Alakangas et al. 2009). In 2007, there were about 1.2 million residential buildings including more than one million detached and semi-detached houses, 74,000 attached houses, and 55,000 blocks of flats. In addition, there were fewer than half a million summer cottages in Finland (Tilastokeskus 2010c). Figure 1 shows the distribution of residential buildings by type of heating fuel (%) since 1991 in Finland. Most of the residential buildings have been heated by electricity.



	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Coal, coke	0,8	0,8	0,8	0,8	0,8	0,8	0,7	0,7	0,7	0,7	0,7	0,7	0,6	0,6	0,6	0,6	0,6	0,6
Other, unknown	1,6	1,7	1,7	1,7	1,7	1,8	2,5	3,3	3,2	3,6	3,3	3,3	3,3	3,4	4,0	4,1	4,2	3,9
District heating	8,5	8,6	8,7	8,9	9,0	9,1	9,1	9,1	9,2	9,3	9,5	9,6	9,6	9,8	10,0	10,2	10,3	10,5
Wood, peat	29,3	28,9	28,2	27,8	27,3	27,0	26,4	25,9	25,6	25,0	24,6	24,2	23,8	23,5	22,9	22,4	22,0	21,8
Oil, gas	26,8	26,7	26,5	26,4	26,3	26,2	26,0	25,6	25,4	25,2	25,3	25,0	24,8	24,5	24,1	23,9	23,7	23,5
Electricity	32,9	33,3	34,0	34,4	34,9	35,2	35,3	35,4	35,8	36,2	36,7	37,2	37,7	38,1	38,4	38,8	39,3	39,8

Figure 1. Percentage of residential buildings by type of heating fuel (%) since 1991 in Finland

(Source: Statistics Finland, 2010b).

The number of residential houses using a wood pellet heating system is estimated to be around 10,000, equivalent to about 1% of all single-family houses in Finland (Piippo, 2007). In Finland, wood pellets are a rather new fuel in space and residential heating since wood pellets were only introduced here in the late 1990s (Heinimö 2008). Since wood pellet production started in 1998 in Finland, production increased to 326,000 tons in 2007 (Alakangas et al. 2009). The total amount of wood pellets used in Finland in 2007 was 117,000 tons, which corresponds to 36% of wood pellet production: 61,000 tons of Finnish wood pellet use were in households and 56,000 tons in medium scale (>25 kW). (Alakangas et al. 2009) The majority of Finnish wood pellets are exported (Heinimö 2008; Alakangas et al. 2009), for instance, to Sweden, Denmark, the Netherlands, the UK, and Belgium (Alakangas et al. 2009).

In Finland, private customers, house corporations, and firms and municipalities can apply for subsidies for adopting wood pellet heating systems (Tuohiniitty 2009). Households, especially with small incomes, can also apply for the subsidy (Tuohiniitty 2009; ARA 2010). In addition, housekeeping costs could be reduced (Tuohiniitty 2009). Moreover, Finland provides investment grants for long-term research into innovative projects and novel sustainable technologies as well as taxation aims to promote renewable energy in Finland. (McCormick & Kåberger 2007)

In conclusion, global awareness of bio-energy technologies has increased rapidly over the past decade. The use of renewable energy has been estimated to have increased in the Finnish residential heating sector (Alakangas et al. 2005). Finland has the potential for by-products of the wood

industry, and a large amount of wood pellets has already been produced. However, the majority of wood pellets are exported. To heat a residential house using wood pellets as fuel, a wood pellet heating system is needed. Wood pellet heating systems are rather new in Finnish heating markets and have been rarely adopted compared to other European countries. Thus, to face the competition, the demand-side factors, especially adoption attributes, should be studied. Accordingly, the following section presents the research questions and objectives of this research.

1.3. Research questions and objectives

Besides the contextual driving forces and the development of innovative technologies for more sustainable energy production and utilization, a recurring theme in the literature is the observation that whenever a cleaner or a cost-reducing technology is available on the market, its uptake across households takes several years and in some cases even decades (Battisti 2008). The technology itself and the bundles of services and additional features related to the basic technology affect the acceptance of the system in the market.

In order to develop and market innovations, an understanding of factors promoting and constraining adoption, and also how the factors influence the rate and level of diffusion within different markets and populations, is needed (Tidd & Bessant 2009). A better understanding, for instance from a managerial perspective, of what influences the decision to adopt or reject a wood pellet heating system might help to this system to compete successfully against rivals in residential heating markets. Issues, particularly practical requirements for increasing the number of adoptions of wood pellet heating systems, leaves a considerable need to combine adoption of innovation theories and the attributes influencing the decision to adopt of the wood pellet heating system. Hence, the driving force for this research was a practical interest to study what influences the decision to adopt a renewable residential heating system.

A lot of theoretical work has been done to study the adoption of innovations, as described in the next chapter. Adoption of innovations has been studied through many approaches and perspectives, for instance, in terms of diffusion of innovations (Rogers 2003), from both the demand and supply sides (Tidd & Bessant 2009). Despite the noticeable prior work on adoption of innovations in a residential heating context (Mahapatra & Gustavsson, 2008a, 2008b, 2009), there is a lack of academic literature on the attributes influencing the decision to adopt wood pellet heating systems.

The research question of the thesis has been evolving in recent years as the research has been carried out and articles related to it have been written up. The main research question that has been developed is formulated as follows: **What influences the decision to adopt wood pellet heating systems?** The research question is rather broad, and too complex to be approached as such; thus, this research applies the customer and innovation perspectives, thus focusing on the demand side, in order to limit the scope of the research. The customer perspective on adoption attributes focuses on personal attributes, i.e., age and gender, in relation to perceived familiarity, knowledge, and intention to adopt; and on perceived barriers and factors influencing the decision to adopt wood pellet heating systems. The innovation perspective focuses here on the adoption of innovation theories, particularly characteristics of innovation (Rogers 2003), value for the customer (e.g. Woodall 2003), and communication activity. Thus, the research question is divided into five research questions and targets. Answering the five questions posed should identify the attributes of

customers and characteristics of innovation influencing the decision to adopt wood pellet heating systems. The research questions are initially discussed below.

The first article, i.e. the first paper of the initial publications of the research, focuses on examining whether customers' personal attributes, i.e., age and gender, have an influence on the decision to adopt wood pellet heating systems. Gender and age are the basic personal attributes of the customers. The target is to examine whether age or gender influence perceived familiarity and knowledge regarding wood pellet heating system issues or the intention to adopt a new heating system. Thus, the first research question (Q1) is formulated as follows: Do customers' personal attributes influence the decision to adopt wood pellet heating systems?

Publications are one source of information in the residential heating context (Mahapatra & Gustavsson 2008a); thus, they provide one communication channel (Rogers 2003) or a way for companies to inform customers. Therefore, in the second article, we assess the discussion of wood pellet heating systems through publishing activities in different sources. In addition, communication channels are part of innovation decision process; thus, the communication activity supports researchers' interest in studying perceived knowledge in the decision to adopt wood pellet heating systems. Moreover, the study attempts to obtain some technology lifecycle indicators to evaluate, at least roughly, the development phase of wood pellet heating systems through publication activity (Watts & Porter 1997). Thus, the second research question (Q2) is formulated as follows: How and in what sequence is information on wood pellet and related technologies communicated in different sources?

The third and fourth articles study adoption attributes from theoretical innovation perspective, and focus on perceived adoption factors, i.e. barriers, as well as criteria and categorization according to characteristics of innovation. The third article categorizes the perceived barriers to acquiring wood pellet heating systems according to characteristics of innovation. Thus, the third research question (Q3) is formulated as follows: What is the categorization of the perceived acquisition barriers of wood pellet heating systems according to characteristics of innovation? A variation in categorization might indicate differences in perceived barriers and in the characteristics of innovation influencing the decision to adopt wood pellet heating systems.

The fourth article first examines perceived adoption criteria affecting the decision to adopt wood pellet heating systems and, second, categorizes perceived factors according to characteristics of innovation. Thus, the fourth research question (Q4) is formulated as follows: What are the perceived adoption criteria for wood pellet heating systems and their categorization according to characteristics of innovation? The research focuses on the concept of characteristics of innovation. Therefore, the target of the article is to review the characteristics of innovation literature (1986-2008) and give an empirical determination of the characteristics of innovation as a framework for categorizing perceived adoption criteria. This literature review and determination might firstly indicate the usability of characteristics of innovation as a framework and, secondly, the differences in perceived criteria influencing the decision to adopt wood pellet heating systems.

Finally, the fifth article continues the discussion about factors influencing the adoption of wood pellet heating systems. The target is to analyze the categorization of perceived acquisition criteria according to characteristics of innovation and analyze the results theoretically from value for

customer perspective. Thus, the fifth research question (Q5) is formulated as follows: What is the value for the customer in the context of categorization of perceived acquisition criteria for wood pellet heating systems according to the characteristics of innovation? The article combines theoretical customer and innovation perspectives with a view to analyzing the results of the categorization.

Overall, the five research questions are somewhat different in nature. The first and the fifth articles relate theoretically to the customer perspective and the second, third, and fourth articles relate theoretically to the innovation perspective. The second article studies publication activity as a communication channel for customers of wood pellet heating systems, thus the second article is the least important in the research. The third and the fourth articles study adoption attributes from a theoretical innovation perspective and focus on perceived acquisition factors, as well as categorization according characteristics of innovation. The fifth article summarizes the categorization of perceived acquisition factors according to characteristics of innovation and theoretical value for the customer, concluding the somewhat qualitative analyses of the results. For the sake of simplicity, all research questions refer to possible adoption attributes influencing the decision to adopt wood pellet heating systems. Figure 2 demonstrates the division of topics for the different articles. All articles are related in some way to both innovation and customer perspectives; thus, the solid lines illustrate the primary theoretical focus and dashed lines the contextual focus from the perspective of the subject of the article.

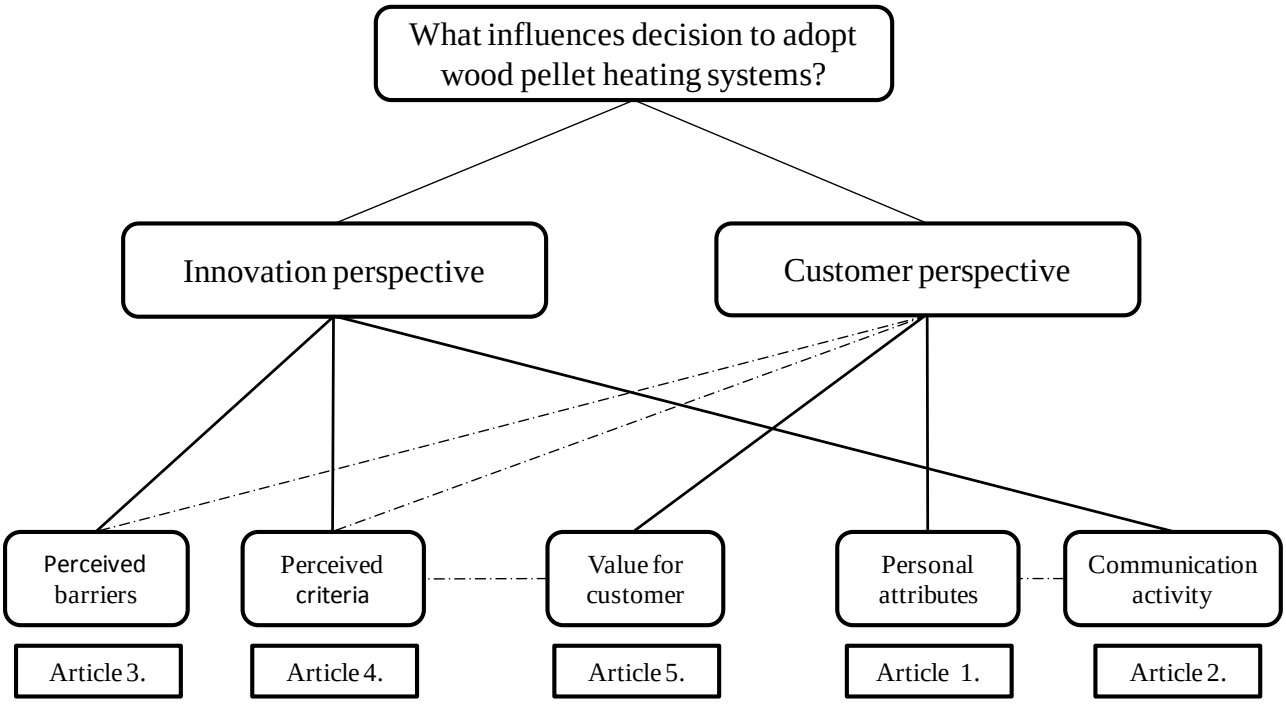


Figure 2. Division of subjects of the articles

By answering the research questions and addressing the attributes of customers and characteristics of innovation, this research critically considers attributes influencing the decision to adopt wood

pellet heating systems. In addition, these research questions show the relevance of adoption of innovation research in the context of residential heating systems.

1.4. Settings of the research

Choices have been made in order to answer the challenges posed by the research questions and objectives. Therefore, after discussing the general outline of the research, the research design and the realization of the selected methods are described.

1.4.1. General outline of the research

Identifying a research area may be derived from several sources, for instance, personal interest or experience, theory, the research literature, a question, new developments in society, or a social problem (Bryman & Bell 2007: 82-85). However, research can also be viewed as a series of interlocked, even simultaneous, choices (McGrath, Martin, & Kulka 1982). Here, the main source for the research area was the practical interest in understanding the adoption of wood pellet heating systems. After starting out with a general research area, narrowing down the focus of research may help with developing research questions. Research questions will guide the literature review, research design, and data collection, and also help in analyzing and writing up the data (Bryman & Bell 2007: 83). Thus, several informal research questions were composed for this research. The practical interests and existing literature provided ideas for questions. However, it may not be possible to answer all the research questions that arise (Bryman & Bell 2007). Therefore, the selections in this research were based on collaboration with wood pellet heating companies. To summarize, the practical aim of this research was to collect information on potential customers and gain their opinions on wood pellet heating technology and services, and particularly to identify the factors influencing the adoption of the wood pellet heating system.

Because of the relevance of research to practitioners, this research can be categorized as business research. In addition, different approaches might be used to explore the research (Bryman & Bell 2007: 4-36). Business research has been commonly distinguished according to quantitative and qualitative research practices, which constitute different approaches to social investigation (Bryman & Bell 2007: 4-36); in these practices, the use of theory may serve different purposes. In quantitative research, theories provide proposed explanations for the relationship among the variables being tested. In qualitative research, theories may serve as a lens for the inquiry or are generated during the study. In mixed-method studies, researchers employ theories in many ways. (Creswell 2003) Combining quantitative and qualitative approaches may provide different conclusions (Metsämuuronen 2003: 207-209). In order to come to more robust conclusions, this research applies both quantitative and qualitative approaches.

In addition, other approaches might guide the research. Briefly, with a deductive approach, theory guides the research, so that the researcher begins by testing or verifying the theory. In contrast, with an inductive approach, one outcome of the research will be the generation of a theory to account for past experiences and findings reported in the literature (Bryman & Bell 2007: 11-15; Creswell 2003: 119-141). However, characterizing the nature of the link between theory and research is not straightforward (Bryman & Bell 2007: 7). Rather, this research is the outcome an iterative process, weaving back and forth between data and theory.

Philosophically, researchers make ontological claims about what knowledge is, and epistemological claims about how knowledge is acquired (Creswell 2003: 6). In other words, ontological issues are concerned with the nature of social entities, for instance, whether social entities should be considered objective entities that have a reality external to the social actor, or whether social entities should be considered social constructions that are built up from social actors' perceptions and actions. Epistemological issues relate to knowledge about the social world, for instance, whether a natural science model of the research process is suitable for the study of the social world or not. (Bryman & Bell 2007: 4-36) The traditional approach states that knowledge is justified true belief (Steup 2005). Post-positivism, however, challenges the absolute truth of knowledge and recognizes that we cannot be "positive" about our claims of knowledge when studying the behavior and actions of humans (Creswell 2003: 6-8; Metsämuuronen 2003: 163-166). However, this research is based on the assumption that the customers are able to make adoption decisions and explicitly describe their perceived acquisition factors in relation to wood pellet heating systems. What kind of knowledge can be obtained based on this research is discussed and assessed in the chapter 4.

1.4.2. Research design and methods

Here, the research design and the realization of the methods selected for the research are described. The research design provides a framework for data collection and analysis. The research design is connected to understanding behavior in specific social contexts and having a temporal appreciation of social phenomena. (Bryman & Bell 2007: 40) Five prominent research designs are the experimental, longitudinal, case study, comparative, and cross-sectional design. A cross-sectional design entails the collection of data for more than one case at a single point of time in order to collect a body of quantitative or quantifiable data in connection with two or more variables, which are then examined to detect patterns of association. Cross-sectional research is associated with social surveys, but could also include structured observation, content analysis, official statistics, and diaries. The most common form of cross-sectional design is social survey research. (Bryman & Bell 2007: 39-55)

A research method is simply a technique for collecting data (Bryman & Bell 2007: 40; Metsämuuronen 2003: 162-163). Data are collected in connection with variables, which are then examined to detect patterns of association (Bryman & Bell 2007, p. 55-56). A variable is simply an attribute on which cases vary; without variation, an attribute is constant. There is a basic distinction between independent and dependent variables. (Bryman & Bell 2007: 42)

Due the practical outline of the research and the formulated research question, this research focuses on the demand side of the adoption of the innovation, particularly residential customers. Hence, the social survey, and particularly the questionnaire, was selected as a research method in order to collect information on customers and gain understanding of their perceptions and opinions on wood pellet heating technology and services. The survey as the choice for a research method may be challenged on many fronts. The main errors in survey research are sampling and non-sampling errors, even though probability sampling is employed, and data processing errors that arise in the coding of answers. (Bryman & Bell 2007: 204). However, the insights gained from the survey can both make the research better and provide useful insights into the basics of social interaction

(Krosnick 1999). The original questionnaire could be asked from the author. Population, sample, questions, and inducement are features of the survey; these are discussed below.

Population is the universe of units from which the sample is to be selected (Bryman & Bell 2007: 182). Because of the practical background of our research question, the population of the research could be referred to here as the customers for the wood pellet heating system in the residential heating market in Finland. However, because wood pellet heating systems can be installed for both new and renovated houses, the exact number of people the research covers is vague. Customers might have none or even several houses; either way, they usually include some type of heating system, at least in Finland. Thus, the distinction between homes and second homes, such as summer cottages, in the residential markets is not studied here. If every existing house had a wood pellet system installed, in Finland there would be over one million single-family houses (Central Statistical Office 2007) heated by wood pellets; this provided the limit for the population. However, the limit is skewed in the sense that every single-family house should be heated by only one method. With the global perspective, wood pellet heating systems could be exported; thus, the population could be all customers who heat their residential houses.

Sample is defined as the segment of the population selected for investigation as a subset of the population (Bryman & Bell 2007: 182). Sample types are random sample, systematic sample, stratified sample, cluster sample, and snowball sample (Metsämuuronen 2003: 31-33). In survey studies, if strict statistical sampling is not feasible, other procedures may be invoked to enhance the representativeness of individuals in the research; for instance, it may be possible to replicate the study with different subgroups of the target population (Calder, Phillips, & Tybout 1981) and a survey could be conducted through representative sampling (Krosnick 1999). We accepted into our sample all adult respondents, regardless of the heating systems they were using because, according to Rogers (2003), previous adoption can lead to continued adoption, or a previous rejection decision can lead to a later adoption decision. Hence, there was no attempt to restrict the survey to actual customers of wood pellet heating for single-family houses, even though this may have given different research results. Of the total number of respondents (N=154), two thirds were men and one third women. Over half (53%) were selecting a new heating system and just under 77% had considered adopting the wood pellet heating system, furthermore, just under 47% of respondents (n=149) were both selecting a new heating system and had considered adopting the wood pellet heating system (Tapaninen 2008), which improves the reliability of the results that are gained from the sample.

In addition, the Housing Expo was considered a suitable venue for the survey, since the event provides a showcase for companies to exhibit their products and services and also to attract customers and gain feedback. The Housing Expo was held between July 13, 2007 and August 12, 2007; over 195,000 visitors attended, which corresponds to 3.8% of the national population of Finland. Visitors to the exhibition are typically interested in housing and house-building technologies and, thus, are likely customers for wood pellet heating.

Another reason that survey method is challenged is that, for instance, different phrasings or formats of questions might yield different results (Krosnick 1999; Schwarz 1999). With questionnaire pretesting, questions that respondents might have difficulty understanding or might interpret

differently than the researcher intended can be identified (Krosnick 1999) and revised (Bryman & Bell 2007: 181). Thus, in the current research, empirical data collection was carried out in two parts. Firstly, the initial design of the survey was pretested (Czaja & Blair 2005). A few clarifications were made after pretesting, for instance, clarifying the phrasing of questions in order to finalize the questionnaire.

Questions usually have some assumptions behind them. This research assumes that residential heating systems may exhibit specific characteristics of adoption (Berkowitz & Haines 1982). Customers react to the characteristics of heating technology (Berkowitz & Haines 1982), evaluate the value for the customer (Woodall 2003) and perceived characteristics, and decide either to adopt or to reject the system (Berkowitz & Haines 1982; Rogers 2003). Thus, this research assumes that the respondents are able to make adoption decisions and explicitly describe the perceived factors that they consider when deciding whether to acquire wood pellet systems. The research considers that the responses are all equally informative in providing insights into the minds of respondents (Krosnick 1999).

As an inducement to participate, each respondent received a wood pellet brochure worth five euros, which might be considered rather a small inducement compared to the costs of acquiring the wood pellet heating system, which could run to several thousand euros.

In order to analyze the responses, for the comparison of distribution, Pearson's classical chi-squared test (χ2-test) is used. The chi-squared test is a statistical technique to determine significant differences between two or more series or proportions (Metsämuuronen 2003). The chi-squared test is used to test one argument as the null hypothesis. In every cell, there must be at least one count and expected less than five counts is an optimum (Metsämuuronen 2003). Chi-squared test results under $p \leq 0.01$ or $p \leq 0.05$ is significant in the selected risk percent. In addition, this research employed a content analysis that can be briefly defined as a systematic, objective, quantitative analysis of message characteristics (Bryman & Bell 2007: 302).

In addition, content analysis is one technique in quantitative research. Rhetorical, narrative, discourse, structuralist or semiotic, interpretative, conversation, and critical analysis are techniques of content analysis. We used an interpretative technique of content analysis that targets the formation of theory from the observation of messages and the coding of those messages. (Neuendorf 2002) Furthermore, we applied the Krippendorff's alpha (K-alpha) technique to assess the reliability of multiple classifiers' evaluations in content analysis. This describes the extent to which independent classifiers evaluate each item and reach the same conclusion (Krippendorff 2004). In this research, K-alpha indicates the extent to which the different classifiers tend to ascribe the same factor to the same category.

In this research, a bibliometrical method was also applied in order to fulfill the targets of the research with publication activity indicators. It is the quantitative study of literatures, and its task is to provide evolutionary models of science and technology (White, McCain 1989). It is defined as a general means for measuring texts and information (Borgman & Furner 2002). Overall, indicators can be devised through questions, the recording of individuals' behavior, official statistics, or an examination of mass media (Bryman & Bell 2007: 159). Bibliometrics is one approach to measuring mass media. The bibliometric analysis approach includes three measurement

concentrations: activity measurement, linkage measurement, and impact measurement (Gerdsri & Daim 2008). However, the life cycle indicators in assessing the phases of green technologies are criticized, that there is no absolutely obvious sequence of communication activity between the sources (Järvenpää & Tapaninen 2008; Järvenpää & Mäkinen 2009). The activity measurement of the communication seeks general descriptive results, and therefore the bibliometrical method is appropriate for providing indicators for the research. Thus, bibliometrical activity measurement is used here to discuss the progression of communication around wood pellet heating systems.

In summary, the research used the survey method to collect data about customers and their perceptions, and the bibliometrical activity measurement method to examine publication activity regarding wood pellet heating systems, so that the methods were somewhat mixed. The methods chosen have limitations, however, in providing the specified empirical results for the research. Different research approaches and methods could be used in the future studies, or instance, mixed methods research, as a distinct approach, is relatively new in the social and human sciences (Creswell 2003: 209).

2. LITERATURE ON ADOPTION OF INNOVATIONS

Definitions of the concepts used in this thesis are discussed in the current section in order to set the boundaries for the theoretical background of the research. Definitions describe subjects, as such, but also exclude other subjects (Braun 1998: 8). Thus, definitions might reveal gateways and set boundaries for the research.

2.1. Innovation perspective

The vast literature on adoption of innovations is fragmented and multidisciplinary. This thesis focuses on literature about diffusion of innovations, the innovation decision process, and characteristics of innovation, as described below.

2.1.1. Diffusion of innovations

The diffusion of innovation research began during the 1940s (Rogers 2003: 39). The nine major diffusion research traditions are anthropology, early sociology, rural sociology, education, public health and medical sociology, communication, marketing management, geography, general sociology, and other traditions. Traditionally, marketing managers have been concerned with how to launch new products successfully, the rate of adoption, and how the perceived attributes of an innovation influence the adoption rate. Marketing scholars argue that they provide a useful contribution by helping to identify customers' needs (Rogers 2003: 39-101). Hence, the diffusion of innovations has been studied using different approaches, focusing on particular aspects, and adopting different methodologies. For instance, economists try to explain past behavior and predict future trends, marketing studies have examined buyer behavior, and development economics has studied the adoption of agricultural innovations (Tidd & Bessant 2009: 351-352). In addition, diffusion of innovations studies include many thematically different discussions. Management issues, for instance, include studies regarding innovation diffusion and technology acceptance (Carayannis & Turner 2006), launch strategy, launch tactics, and demand outcomes (Guiltinan 1999), while the sustainable diffusion of renewable energy technologies is an example of an innovation-focused policy (Tsoutsos & Stamboulis 2005). In energy and fuels, issues that have been studied include housing associations (Egmond, Jonkers, & Kok 2005, 2006b) and the importance of target groups (Egmond, Jonkers, & Kok 2006a, 2006c).

Research on diffusion aims to study what influences the rate and direction of adoption of innovation (Tidd & Bessant 2009: 352). Since the Bass (1969) model was introduced, the diffusion of innovations has been widely studied (Mahajan, Muller, & Bass 1990). Rogers (2003) has defined diffusion as the development in which innovation proceeds through specific channels of communication and members of a social system over time. Hence, diffusion describes how the adoption of the innovation increases over time as the communication of the innovation changes. Communication, meanwhile, is a process whereby information or ideas are shared and exchanged (Rogers 2003). Thus, four elements are included in the diffusion research: innovation, communication channels, a social system, and time, as described below.

Firstly, the term innovation has many meanings. Innovation can refer to the inventive process by which new things, ideas, objectives, and practices are created; it can mean the new thing, idea, or

practice itself; or it can describe the process whereby an existing innovation becomes part of an adopter's cognitive state and behavioral repertoire. (Goldsmith & Foxall 2006) Innovations are also seen as the result of an interactive process of knowledge generation, diffusion, and application (Tödtling, Lehner, & Kaufmann 2009). If an idea is new to customer, it is an innovation. Knowledge, persuasion, or decision to adopt may express newness. (Rogers 2003) In short, innovation reflects the metamorphosis from present practice to a new, probably improved practice. This research adopts a view in which innovation refers to a new technological entity that is used in improving its adopters' processes.

Secondly, communication is defined as the process by which customers create and share information with each other. Diffusion is one type of communication, in which the new idea is in the content of communication. A communication channel is defined as the means by which messages get from one place to another, for instance, through mass media or interpersonal channels. (Rogers 2003: 1-38) Communication channels could be examined in both quantitative and qualitative studies. For instance, the communication channel frequency of communication content could be determined (Mesch 2009).

Thirdly, a social system is a set of interrelated units. The members of units may be individuals, organizations, or subsystems. The social system may affect innovation, as well as acting as a boundary for innovation diffusion. (Rogers 2003: 1-38) For instance, all residential houses in Finland or family members living in a house could be seen as a social system.

Fourthly, time is also an element of diffusion. The time dimension is involved: 1) in the innovation decision process, 2) in the relative earliness or lateness of the adoption of the innovation, and 3) in the rate of adoption of innovation (Rogers 2003: 1-38). However, diffusion of innovations studies should also acknowledge the probability of rejection, discontinuance, and reinvention (Rogers 2003: 114), which might generate biased results. Thus, measuring time could be both a strength and weakness in diffusion of innovation studies.

In addition, some criticism is presented regarding the diffusion of innovation research. Criticisms of diffusion research concern the pro-innovation bias, the individual-blame bias, the recall problem, and the issue of equality (Rogers 2003: 105-135). The evaluations of these biases are described in 4.3, the assessment of the research section.

As a conclusion, diffusion of innovation delineates the adoption of innovation. Adoption of innovations can also be distinguished in innovation evolution, which has generally been divided into phases of initial slow growth, then accelerating growth, and finally maturity and decline (Bass 1969; Gort & Klepper 1982; Rogers 2003), which are typically modeled on an S-shaped diffusion curve using mathematical methods (Meade & Islam 2006). In other words, the S-curve represents the rate of adoption over time. Hence, an increasing rate of adoption of innovation demonstrates the acceleration of diffusion. The pattern of the adoption of innovation is based on the interaction of demand-side and supply-side factors (Tidd & Bessant 2009).

2.1.2. Innovation decision process

A new idea or technology might be evaluated and the decision made to adopt after series of choices and actions. An adoption decision that occurs over time and consists of series of different actions is called an innovation decision process (Rogers 2003). The innovation decision process, as formulated by Rogers (2003), is given in Figure 3.

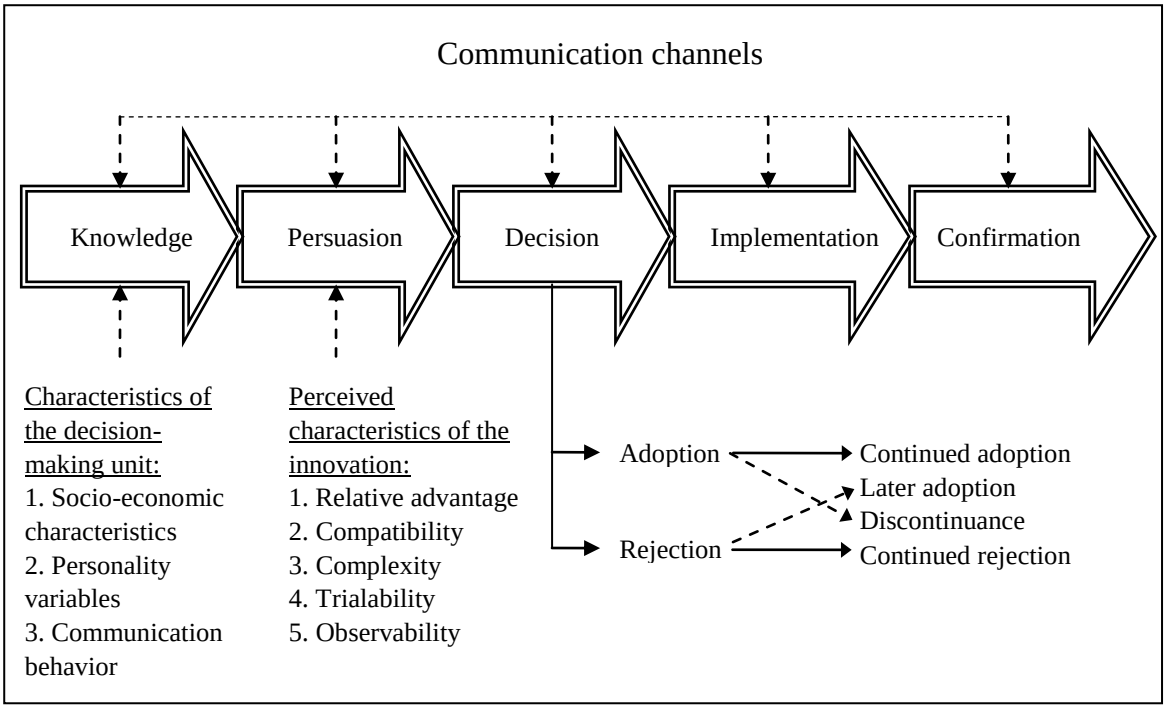


Figure 3. Innovation decision process (Rogers 2003: 170).

The stages of innovation decision are defined as follows: In the knowledge stage, the customer is aware of the existence of an innovation and understands some of its functions. Prior conditions such as previous practice, felt needs/problems, innovativeness, and norms of the social system influence knowledge. Prior conditions could be obtained in different ways, e.g., whether a previous practice or need leads a customer to seek certain information about innovation or vice versa. Mass media channels are relatively important at the knowledge stage. Persuasion is the stage when the customer has an attitude with positive or negative associations related to the innovation. At the persuasion stage, interpersonal channels are emphasized. The customer makes a decision, choosing between adoption and rejection of the innovation. As a result of the adoption or rejection decision, consequences, whether desirable versus undesirable, direct versus indirect, or anticipated versus unanticipated, could occur as changes to the customer or the social system. After the decision to adopt an innovation is made, the customer implements the innovation for use. Finally, in the confirmation stage, the customer's decision is reinforced or reverts to the previous decision level. (Rogers 2003)

The innovation decision process has been applied in the literature, for instance in observing the act of specification (Emmitt 2001). Based on Rogers' (2003) innovation decision process, Kapplan has generated a conceptual model (Kaplan 1999a, 1999b). In addition, Mahapatra and Gustavsson have adapted Rogers' innovation decision model and formulated four stages of decision making involved

in homeowners' adopting an innovative heating system. The stages are as follows: 1) need for a new system, 2) plan for a new system, 3) collection of information, and 4) selection of a system. Factors influencing decisions are: socioeconomic characteristics, mass media and interpersonal communications, and relative advantage in relation to technical, level-of-comfort, economic, and environmental issues. In addition, the macro environment influences decision making. (Mahapatra & Gustavsson 2008b, 2009) Both decision models are consistent with a focus on the need, information, and decision. The models conflict slightly, as Mahapatra and Gustavsson (2008b, 2009) highlight the plan for the system, as well as economic and environmental factors influencing the selection of a system in the innovative heating context.

Hence, the adoption of innovation decision process is defined as the decision to make full use of an innovation. The opposite is reflection, referring to a decision not to adopt an innovation. However, this decision could be reversed later on. Innovations can be adopted or rejected by individuals or by entire social systems; this is based on the assumption that individuals can make an optional decision and social systems can make a collective or authorized decision. (Rogers 2003)

The perceived newness of innovation and associated uncertainty are distinctive aspects of innovation decision making (Rogers 2003). However, the process model of the decision to adopt is a rather rational way of thinking, which includes only certain stages, characteristics, and conditions. Because of the multiple stages necessary, the decision to adopt as a process might take some time. The length of time required to pass through the process, defined as the *innovation decision period*, might be many years for some customers, while others move rapidly from knowledge to adoption decision and implementation (Rogers 2003). However, customers might make the adoption of innovation decision instantaneously, for instance with durable goods.

Direct or indirect incentives are provided to encourage the adoption of innovation and to speed up the diffusion. Incentives might vary in form as follows. 1) Incentives may be paid directly to adopters or to the diffuser who persuades an adopter. 2) Incentives may be paid to individuals or to the system to which they belong. 3) Positive incentives might reward the adoption of innovation but also penalize customers by imposing a penalty or by withdrawing the desiderata that might influence the persuasion of the relative advantage of decision to adopt an innovation. 4) Incentives might be financial payments but also take the form of a commodity or desired object. 5) Incentives may be paid immediately at the time of adoption but also after the adoption. (Rogers 2003: 236-239) Adoption, in general, is the decision to acquire something, whereas implementation and utilization could be considered to imply some action (Tidd & Bessant 2009). However, associated terms such as adoption, implementation, or utilization may have various definitions. In general, *adoption* is the action or fact of adopting or being adopted. To *implement* is to put a decision, plan, agreement, etc., into effect. *Utilize* means making practical and effective use of some objective. In addition, *acquire* refers to buying or obtaining an asset or object, or learning or developing a skill, habit, or quality. (Dictionary of English 2006)

In conclusion, making the adoption decision might include different stages in different contexts, and the attributes influencing this decision might overlap or be more or less different. Such issues provide topics for future diffusion research examining the decision to adopt innovations, the characteristics of innovation, or attributes influencing the adoption decision.

2.1.3. Characteristics of innovation

Several variables and attributes might affect the adoption of innovation (Tidd & Bessant 2009: 355). The perceived characteristics of innovation might help to explain the different rates of adoption of innovations (Rogers 2003). According to Rogers (2003), between 49% and 87% of the variance in adoption can be explained in terms of five attributes: relative advantage, compatibility, complexity, trialability, and observability. These are discussed below. However, percentages might differ in different contexts; for instance, Kendall et al. (2001) found the regression of five characteristics innovation explaining only 36% of willingness to adopt electronic commerce.

In the literature, characteristics of innovation are utilized both to explain innovation adoption post hoc (e.g. Cale & Eriksen 1994) and to predict the adoption intention (Fu et al. 2007; Greer & Murtaza 2003). The role that characteristics of innovation play in the adoption of an innovation has been studied extensively (Al-Gahtani 2003; Hayati & Jowkar 2008; Lee 2004; Martins, Steil, & Todesco 2004; Ortt 1998; Völlink, Meertens, & Midden 2002). These studies indicate that perceived characteristics may take different forms in different countries (Al-Gahtani 2003; Hayati & Jowkar 2008) or in different contexts (Lee 2004; Martins et al. 2004). The attributes of innovation themselves may also be perceived as barriers to adoption (Völlink et al. 2002). In addition, characteristics of innovation are utilized for a wide range of topics, for instance in relation to learning and teaching (Fu et al. 2007; Martins et al. 2004; Shelley 1998) and the subject of computer science (Iivari 1995; Kendall et al. 2001; Lee & Kozar 2008).

In addition, many researchers have previously studied characteristics of innovation regarding energy issues (Faiers, Neame, & Cook 2007; Labay & Kinnear 1981; Mahapatra & Gustavsson 2008a, 2008b 2009). Mahapatra and Gustavsson (2008b) analyzed the diffusion patterns of innovative residential heating systems in Sweden with an adopter-centric approach, and also homeowners' perceptions and factors influencing their choice of heating system with innovative approaches to domestic heating (2008a), and factors influencing Swedish homeowners to adopt district heating systems (2009). Faiers, Neame, and Cook (2007) have studied whether consumers assess product attributes in a stepwise process in the adoption of domestic solar-power systems. Labay and Kinnear (1981) studied the consumer decision process involved in the adoption of solar energy and reported major differences on many measures between adopters and non-adopters.

Moreover, many researchers have applied survey or questionnaire methods to study characteristics of innovations on many fronts (Hayati & Jowkar 2008; Kendall et al. 2001; Martins et al. 2004; Shelley 1998). For instance, they have studied: factors influencing the adoption of the Internet as a teaching tool at foreign language schools (Martins et al. 2004); receptivity of Singaporean small and medium-sized enterprises to electronic commerce adoption (Kendall et al. 2001); adoption of electronic reference materials in academic libraries (Hayati & Jowkar 2008); or factors that affect the adoption and use of electronic mail by K-12 foreign language educators (Shelley 1998).

The idea that characteristics of innovation represent the customers' perception of an innovation originated in the social sciences in the domain of agricultural practices (Rogers 1961; Fliegel & Kivlin 1966). Since Fliegel and Kivlin (1966) studied the 15 attributes of innovation as factors in diffusion in the farming context, the number and definitions of innovation attributes have changed and formulated into characteristics of innovation. In the first edition of *Diffusion of innovations*,

Rogers (1962) utilized five characteristics of innovation: relative advantage, compatibility, and complexity and in addition divisibility and communicability. In the latest edition (Rogers 2003), divisibility and communicability are not mentioned, but trialability and observability have been added to the characteristics. *Divisibility* is perceived when an innovation could be tried on the limited basis. Innovations can be sampled using small-scale trial and trial over time. *Communicability* is when some ideas are easily observed and communicated to others. (Rogers 1962: 132-133) Perceived divisibility and communicability of innovation affect its rate of adoption. In the first edition of *Diffusion of innovation*, Rogers highlighted that "It matters little whether or not an innovation has a great degree of advantage over the idea it is replacing. What does matter is whether the individual perceives the relative advantage of the innovation" (Rogers 1962: 124). Ostlund (1974) studied a set of six characteristics: relative advantage, compatibility, complexity, trialability, observability, and additional perceived risk; these are viewed as separate dimensions in the customers' evaluation, and are independent variables in the characteristics of innovation.

Finally, the 1995 and 2005 editions of Rogers' *Diffusion of innovation* include five perceived characteristics of innovation: relative advantage, compatibility, complexity, trialability, and observability as a general categorization of characteristics of innovation. Relative advantage, compatibility, and complexity represent the advantages and disadvantages of an innovation, while trialability and observability increase uncertainty as to the value of innovation and, thus, raise the risks of adopting it (Narayanan 2001). Characteristics of innovation are described as follows (Rogers 2003):

> *Relative advantage* is perceived improvement of the innovation over existing solutions. The perception of improvement can be observed in terms of its economic or technical benefits, or some other advantage-producing perspective. The relative advantage has an influence on the rate of adoption of the innovation. The degree of relative advantage can be measured by technical factors, economic factors, or sociological factors such as economic profitability or conveying social prestige. More important than any objective advantage is the perception of a personal advantage.
>
> *Compatibility* is a measure of the suitability of the innovation in both a technical and a social sense. Technical compatibility reflects the appropriateness of the innovation to its intended technical system, i.e., its compatibility with other elements in the technical system. Social compatibility reflects the suitability of the innovation and its use in the potential adopter's use processes and values. Compatibility of the innovation influences the rate of adoption of the innovation.
>
> *Complexity* reflects the degree to which the innovation is difficult and complicated to understand or use. Innovations that are easy to understand are more likely to be adopted than those that demand new skills, knowledge, or understanding.
>
> *Trialability* refers to the extent to which adopters can experience, try, or perceive the innovation before making the commitment to adopt it. Trialability reduces risk perception and thereby increases the rate of adoption of the innovation.

Observability refers to the transparency of the advantages of the innovation to potential adopters. It also relates to the degree to which the benefits can be communicated to others. The level of observability also affects the rate of adoption of the innovation.

The characteristics of innovation concept has been employed increasingly by scholars in analyses of various technological systems in recent years, including those related to energy issues. Many studies have been conducted in different social settings, and have emphasized the incentive and preventive roles of the features of innovation adoption (Tornatzky & Klein 1982). However, while there is general agreement regarding relevant factors, there is little consensus on the relative importance of the different factors and the direction of the relationship. For instance, the complexity of a cooking stove is not a deterrent to successful adoption (Pandey & Yadama 1992). In addition, the stepwise order of characteristics of innovation has been discussed (Faiers, Neame, & Cook 2007). In conclusion, characteristics of innovation have been studied in many contexts, but scantly in terms of wood pellet heating.

2.3. Customer perspective

Differently categorized customers tend to adopt new technologies at different times (Rogers 2003). In simpler terms, adopters of innovation differ from each other (Dickerson & Gentry 1983; Mahajan, Muller, & Srivastava 1990). Some customers may decide not to adopt the innovation at all (Dickerson & Gentry 1983). Customers could be categorized based on their differences, for instance, demographical, psychological, or behavioral differences, or even the different degrees of innovativeness of customers. This research concentrates on the adoption of innovation literature from a customer perspective, focusing to the basic socio-demographic and adopter categories according to Rogers (2003), as well as value for customers (Woodall 2003).

2.3.1. Adopter categories

Socio-demographic categories, adopter categories, and their characteristics are described below. Basic socio-demographic categories, including age and gender, and environmental issues are widely studied in the literature and this research has shown, for instance, that demographics can be useful in profiling environmentally conscious customers (Diamantopoulos et al. 2003). Results, however, are rather contradictory. In adopting a new heating system, customers in the age group 36-45 years were most likely to install a new heating system (Mahapatra & Gustavsson 2008a, 2008b, 2009); however, there was no overall significant relationship between age and plan to install a new heating system (Mahapatra & Gustavsson 2008b). Interestingly, it is claimed that age does not matter in comparing the earlier and later adopters (Rogers 2003); on the contrary, some studies (e.g. Huh & Kim 2008) have suggested that age does matter.

In the residential heating system context, customers' age is likely to influence plans to adopt heating systems (Mahapatra & Gustavsson 2009, 2008a, 2008b). Younger customers usually move from an apartment to a detached house and have less funding to make the decision to adopt energy-related investments. However, older customers are less likely to install a new heating system. (Mahapatra & Gustavsson 2009) Thus, age might refer to the age at which consumers buy a home or remodel their home, including the heating. Hence, age and gender can be a proxy for the situation when customers consider buying a home, including a heating system.

A significant connection has been found between gender and willingness to pay more for environmentally friendly products (Laroche et al. 2001). Moreover, the gender difference in environmentally concerned customers is associated with advertising (Shrum, McCarty, & Lowrey 1995). However, there has been no significant difference found between gender and direct and indirect energy consumption in households (Abrahamse & Steg 2009).

In conclusion, whether age and gender influence adoption decisions in different contexts and within different ideas, products, and systems, leaves topics open for researchers so that they can use basic adopter categorization for managerial advantage. If the basic categorization does not show differences, finer specification of adopter categories might be needed, for instance, for profiling the customers. Therefore, adopter categories from innovators to laggards are described below.

Adopter categories, according to Rogers (2003), are a set of rather ideal types based on level of innovativeness. Innovativeness is defined as when the customer adopts new ideas, products, or systems relatively earlier than other member of a system. On the other words, when customers begin to use a new idea in over-time sequences, adopter categorization is based on the level of innovativeness of members in the social system. (Rogers 2003: 7)

Among the five categories of adopters of diffusion of innovation (Rogers 2003), the time taken to adopt an innovation follows the trend from innovators to early adopters, followed by the early majority, late majority, and laggards. The characteristics of adopter categorization have been generalized into three types: socioeconomic characteristics, personality variables, and communication behavior (Rogers 2003: 288-292). In short, the characteristics of customers in the innovation adoption phases differ (Rogers 2003):

a) Innovators - Venturesome, gate-keeping role, ability to comprehend and request complex technology
b) Early adopters - Respect, localities, change agents, people who check the idea before exploiting it
c) Early majority - Deliberate, largest category
d) Late majority - Skeptical, most of the uncertainty must be removed before adoption
e) Laggards -Traditional, suspicious, the last ones to adopt the innovation

Adoption behavior is influenced by many psychological and contextual factors; thus, characteristics of customers are rather general and not specific to a certain technology or system. For instance, customer needs and wants, and situational aspects, involvement, and knowledge may influence adoption (Ortt 1998: 213-227), and motivation, experience, and familiarity influence interest in adoption (Kaplan 1999a, 1999b).

Studies indicate that the first segment, the innovators, is crucial, since they validate both the functionality of the innovation (Christensen 1997) and the basic existence of the market for technological innovation (Agarwal & Bayus 2002). The second segment, the early adopters, emphasizes usability and reliability. Since the early adopters' technological expertise might be somewhat limited, they need greater technical support than the innovators do. On the one hand, the continuum of characteristics may exist. (Rogers 2003) On the other, the discontinuity between the innovators and early adopters versus the later adopter categories is recognized as a chasm. The shift from the early phases of innovation adoption to the growth phase represents a major challenge for

companies selling new products. (Moore 1999) This is especially the case in international settings, where dramatic differences in innovativeness vary in the sense of national levels of individualism, uncertainty avoidance, and purchasing power (Lynn & Gelb 1996); this may further influence the adoption decision. However, beyond the chasm, the challenge could be turned into a mass-market adoption, like a tornado, when the general market switches over to the new infrastructure (Moore 2005: 13-26). Thus, customer needs, wants, and preferences can be challenging for marketing operations in terms of information sharing due to the heterogeneous nature of markets.

Seeking and processing information are primary activities in the adoption of innovation. *Knowers* of the innovation can be characterized in similarly to the innovator categories. *Early knowers* of an innovation have higher socioeconomic status, more formal education, and more exposure to interpersonal channels and mass media channels of communication; in addition, they have more change agent contacts and exhibit more social participation than *later knowers*. Information seeking and trying to understand the innovation is a social process that relates to some social norms. Questions such as "What?" "How?" and "Why?" are usually asked during the information seeking. (Rogers 2003) Thus, marketing communications, product designs, and advertising messages, among others, could be different for the innovator segment than for the mass markets later in the innovation adoption. Yet, customers' knowledge can be subjective as well as objective (Selnes & Grønhaug 1986). Expertise, experience, and familiarity exist in relation to knowledge (Ortt 1998; Rao & Monroe 1988). *Familiarity* refers to the number of customers' accumulated experiences relating products, and *expertise* refers to the ability to perform well the tasks related to products (Rao & Monroe 1988). Thus, the specific knowledge might be the basis of the overall understanding or familiarity of the technology or phenomenon at issue.

In the residential heating context, customers planning to install a new heating system gather information from the mass media and from interpersonal sources and change agents (Mahapatra & Gustavsson 2008a, 2008b, 2009). Mass media channels are primarily knowledge creators. Interpersonal networks are more important in influencing adoption or rejection. However, installers/vendors are the most important source of information in the residential heating context. (Mahapatra & Gustavsson 2009)

In conclusion, the uncertainty in the characteristics of adopter categories limits the studies of adoption of innovation from a customer perspective. However, because adopters of innovation might differ from each other, marketing managers (Kotler & Zaltman 1971) and policy makers should take account of the possible differences between target group segments. One alternative that is good for one set of consumers might not be good for the others (Egmond, Jonkers, & Kok 2006a, 2006c).

2.3.2. Value for customer

Studying the customer perspective on adoption of innovation involves looking at interaction and feedback between customers and product developers. This perspective considers customer perceptions; likes and dislikes determine what information is reacted to and how it is processed. The use of customers' perceptions in the adoption of innovation is based on the assumption that perceptions of value for the customer directly impact intentions; these, in turn, impact behavior (Bolton & Drew 1991).

Many researchers claim that perceived value for the customer has a motivating impact upon willingness to buy (Dodds, Monroe, & Grewal 1991; Sweeney, Soutar, & Johnson 1999; Zeithaml 1988), or even that it is the key motivator in making a purchase (Treacy & Wiersema 1993). In other words, a purchase may occur if the value proposition is right (Walters & Lancaster 1999), or may not occur if the perceptions of value for the customers are affected by poor performance (Gorth & Dye 1999). However, customers may perceive value differently. It is recognized that each customer has his/her own value model based upon his/her needs and desires (Ravald & Grönroos 1996), demographics or characteristics (Bolton & Drew 1991), and financial resources (Bolton & Drew 1991; Ravald & Grönroos 1996; Zeithaml 1988).

Many researchers highlight the customers' rationality in the perception or determination of value for customer. Studies indicate that customers determine value as an aggregate of weighted variables (Gorth & Dye 1999), or "value proposition" (Dodds 1999). Rational buyers, especially, seek out best value for the customer (Slater & Narver 1994). Such customers might choose one product over another because they believe they will get better value for the customer than they could expect from an alternative. For instance, in the eyes of the customer, value for the customer propositions might degrade with time, and customers might migrate to "newer" alternative products. In such cases, value for the customer is emphasized or intensified, or most overtly exposed, in a competitive environment (Dodds 1999; Woodruff 1997) and is judged relativistically against other competing products (Walters & Lancaster 1999).

In order to face the competition, several practices are suggested for managers for increasing the value for customers. For instance, value for customers can be maximized when the product is of the highest quality, supported by the best service quality, and offered at the lowest price (Dodds 1999). In addition, value for customer–based competitive advantage arises out of "valuable" product attributes, for instance when products are costly-to-copy, rare, non-substitutable, or causally ambiguous (LaPierre 1997).

However, value for the customer can be perceived consciously, unconsciously, or pre-consciously (Gorth & Dye 1999). In addition, value can be perceived from both positive and negative perspectives. Customers could be influenced more by sacrifices than by benefits, or more by loss than gain (Bolton 1998; Ravald & Grönroos 1996). Thus, if perception of risk increases, or in other words predicted sacrifice increases, customers seek enhanced benefits to compensate for this (Ostrom & Iacobucci 1995). From a managerial perspective, therefore, value for the customers might be delivered more effectively by reducing sacrifice than by increasing benefits (Sweeney, Soutar, & Johnson 1999). However, what delivers value for one customer might increase the perceived risk or sacrifice for other.

Researchers have encountered problems in value for customer studies. This is firstly because value for the customer is perceived by the customer (Butz & Goodstein 1996; Woodruff 1997), or exists only on the customers' terms; as a result, the presence or nature of the value for the customer might be assumed incorrectly. Secondly, in competitive markets, value for customer might change over time. It is recognized that customers are not able to reliably predict what they will value in the future (Huber et al. 1997; Woodruff 1997). Furthermore, customers may use the same criteria for judging value for the customer ex ante or ex post, or they may use different criteria (Parasuraman

1997); the latter will apply especially where a purchase is high in credence qualities, e.g. with services such as engineering courses (Patterson & Spreng 1997). In other words, different aspects of value for the customer will have different impacts at different points in the consumption process (LeBlanc & Nguyen 1999; Zeithaml 1988). However, from a managerial perspective, it can also be an advantage that customers might update value-for-the-customer beliefs regarding a specific product/brand/supplier through sequential buying activity (Bolton 1998). Thus, companies may influence customers by promoting value. At the same time, however, customers can be also illogical.

Despite the best product and promotion, the perception of value for the customer may be contextual. The perceived value of an innovation, and hence its subsequent adoption, might depend on individual evaluations and social context (Tidd & Bessant 2009: 354-355). In such a case, value for customer could be delivered by companies integrating environmental, cost, and customer valuation during the product design process (Bovea & Vidal 2004).

Hence, customer value is defined as follows: "Customer value is a customer's perceived preference for and evaluation of those product attributes, attribute performances, and consequences arising from use that facilitate (or block) achieving the customer's goals and purposes in use situations" (Woodruff 1997: 142). Customer value is one of a company's sources for competitive advantage (Woodruff 1997). However, v*alue for the customer* has no clearly defined status. According Woodall (2003), value for customer captures a range of associated, existing concepts, implying an idea of the existence of properties that are perceived or experienced by a customer. Woodall (2003: executive summary) has defined value for customer as "any demand-side, personal perception of advantage arising out of a customer's association with an organization's offering, and can occur as reduction in sacrifice; presence of benefit (perceived as either attributes or outcomes); the resultant of any weighed combination of sacrifice and benefit (determined and expressed either rationally or intuitively); or an aggregation, over time, of any or all of these". Hence, value for customers is related to purchase intentions; perceived value for customer might be to be the key motivator in making a purchase.

The term *value* has plenty of semantic variety, and its appendage *customer value* can represent both customer perceptions and what the customer can deliver (Woodall 2003). Value is described as the regard that something is held to deserve; the importance, worth, or usefulness of something (Dictionary of English 2006).

In conclusion, different customers or customer segments will value different attributes, or the same attributes to different degrees, within the same product (LeBlanc & Nguyen 1999; Parasuraman 1997). However, as value for the customer increases, so does value to the company.

3. SUMMARIES AND FINDINGS OF THE ARTICLES

In this chapter, summaries of the articles are presented. The summaries include the main idea, results, and findings of the articles, concentrating on those parts of the articles that aim to answer the research questions of the thesis, thus, additional information is found in the original articles in the second part of the thesis. Finally, the chapter gives a brief look at the outcome of the articles.

3.1. Profiling the customers

The innovation decision process has traditionally been divided into stages from knowledge to persuasion and decision and finally to implementation and confirmation (Rogers 2003). The target of this first article, originally named *"Do customers' personal attributes matter in the adoption of bio heating?"*, was to empirically study the basic personal attributes of customers, i.e. age and gender, in terms of their influence on customers' perceived familiarity, knowledge, and intention of products. These factors further influence the decision to adopt wood pellet heating system. Thus, for this research, we focus on the following research question: Do customers' personal attributes influence the decision to adopt a wood pellet heating system? However, the findings related to the influence of personal attributes in the literature are rather contradictory (e.g., Mahapatra & Gustavsson 2008b). Hence, profiling of the customers of wood pellet heating systems, at least at the basic demographical level, is needed. Moreover, familiarity exists in relation to knowledge (Ortt 1998; Rao & Monroe 1988), that further influences the adoption decision (Rogers 2003).

The empirical material consisted of a survey (n=154) conducted at the Hämeenlinna Housing Expo Finland in summer 2007. Altogether, 154 people participated in the study; two-thirds were men and the rest were women. Answers to questions about personal information, i.e., gender and age, were compared according to the six questions and tested with Pearson's chi-squared test. The results are shown in Table1.

Table1. Personal attributes comparison according to six questions and the Pearson's chi-squared test results.

Questions	Compared to	N of Valid Cases	Pearson's Chi-Square
1) Are you familiar with the wood pellet heating system for domestic use?	Gender Age	152 150	0.001*** -
2) Are you familiar with the wood pellet fireplace as an additional heating system?	Gender Age	149 147	0.017** -
3) Do you know where you can purchase a wood pellet heating system?	Gender Age	152 150	0.050** -
4) Do you know where you can buy wood pellets?	Gender Age	149 147	0.015** -
5) Are you selecting a new heating system?	Gender Age	149 147	- 0.007***
6) Have you considered adopting a wood pellet heating system?	Gender Age	151 149	- 0.589
*** Significance; p≤0.01 ** Significance: p≤0.05 Uncountable			

From the results, the significance of gender was analyzed in terms of 1) customers' familiarity with the pellet heating system and 2) pellet fireplaces, 3) customers' knowledge of where to purchase a pellet heating system or 4) where to buy wood pellets. In addition, the observed significance results were related by age to 5) the selection of a new heating system. Other results were insignificant or uncountable with Pearson's chi-squared test; for instance, age was found to be insignificant regarding 6) consideration of adopting a pellet heating system. Six results were uncountable with Pearson's chi-squared test because the lack of responses.

Results showed the significance of gender and age in relation to the decision to adopt wood pellet heating systems. The significance of gender was observed in four different questions (1-4), which were about familiarity and knowledge regarding adoption issues related to wood pellet heating. Women were less familiar with wood pellet heating, or at least, women noted their unfamiliarity more often than men. Likewise, the women perceived that they did not have a lot of knowledge related to wood pellet issues. In addition, the test results showed the significance of women's thoughts about their lack of knowledge about pellet heating systems and their relative unfamiliarity with buying pellets or pellet fireplaces compared to men. The results also indicated that age influences the intention to select a new heating system; in particular, customers aged 35-44 were more likely to intend to buy a new system than those aged 25-34 (Tapaninen 2008). Hence, it could be concluded that customers' gender and age influence the decision to adopt a wood pellet heating system.

From the results, it could be concluded that customers' gender influences perceived familiarity and knowledge regarding adoption decision issues for wood pellet heating systems; furthermore, age influences the intention to select a new heating system. Hence, customers' personal attributes influence the decision to adopt wood pellet heating systems. The outcomes of this study have highlighted, firstly, the importance of perceived familiarity and knowledge influencing adoption

issues, and secondly, the implications of profiling customers, especially in the case of wood pellet heating manufacturers.

3.2. Communication activity in the publications

This article was motivated by the results of the previous article, and especially by the variation in perceived familiarity and knowledge in adopting decisions regarding wood pellet heating systems. Communication is the central part of the diffusion of innovations research (Rogers 2003), and publications are one way to inform the customers. Such publications should influence both perceived knowledge and familiarity. Hence, the target of this second article, originally named *"Assessing development phase of emerging technology: the wood pellets case,"* was to assess communication activity in terms of wood pellet systems and related technologies through publications from different sources. This article focused on the analysis of communications in the realm of technologies relating to the actual wood pellet heating system, particularly heating, burning, and other handling technologies. Hence, this research examined the following research question: How and in what sequence is information on wood pellet and related technologies communicated in different sources? In order to answer to the question, we used the bibliometrical method. We used technology life cycle indicators (Watts, Porter 1997) toward different sources, and also use the indicators as a proxy for development status. Accordingly, fundamental research, applied research, development, applications, and societal impacts are steps in the development of R&D. A number of items in different databases are claimed to indicate the development status. (Watts & Porter 1997)

The databases were searched using three keyword combinations, 1) wood pellet, 2) wood pellet AND heating, 3) wood pellet AND boiler OR stove OR conveyor OR storage, to find the relevant results, where AND and OR are Boolean operators. In the first phase, the fundamental research, indicated by the number of items in databases such as the Science Citation Index, was examined using ISI Web of Knowledge, which includes the Science Citation Index database. The second phase, applied research, explored the Compendex database. The third phase, development phase, involved looking through patents and patent applications, using the esp@cenet database, which is an entry-level, internet-based patent document search service. Finally, two phases, application and societal impacts, were combined due to the similarity indications.

The results indicated that the communication activity regarding wood pellets and related technologies has been increasing on many fronts in four different databases. Especially, after 2003, the number of publications in the Science Citation Index and Compendex databases increased compared to previous years. The number of patents has remained relatively low, ten or fewer. The number of news accounts started to increase in 2005.

In conclusion, firstly, the results demonstrated that the wood pellet heating system is gaining a foothold in communication in several kinds of publications; communication has increased during the observation period, especially after 2003. This is demonstrated by rising publishing counts in four measured indicators. The outcome of this study is valuable, on the one hand for potential developers and stakeholders in wood pellet heating system manufacturing and, on the other, for customers' information and education. Both of these elements should influence the adoption of innovation. Secondly, in the study was expected to identify the phase of development, however, if

counting on the indicators to indicate the phase of development, an absolutely accurate phase could not be stated, leaving a challenge for future research.

3.3. Perceived barriers in the decision to adopt

Innovations can initially be adopted or rejected, and then the decision can be reversed later on (Rogers 2003). One explanation for rejection is barriers to adoption. Reports on some critical views of wood pellet heating systems have been presented, for instance, concerning emissions, slagging, the effects of fuel combustion, and burner efficiency (Vinterbäck 2004). However, in order to increase sales, it is also valuable for manufacturers to know the demand-side barriers, particularly perceived barriers influencing the adoption decision. Hence, this explorative third article, originally named *"Characteristics of innovation: a customer-centric view of barriers to the adoption of a renewable energy system,"* studied perceived barriers in acquiring wood pellet heating systems.

The target of this third article was to investigate customers' barriers influencing the adoption decision in classifying the perceived barriers to acquiring the wood pellet heating systems according two different theoretical frameworks: *perceived characteristics* (Rogers 2003) and *basis of competition* (Christensen 1997). Customers' perceived barriers were collected through a survey (sample size N=154) of Finnish housing expo attendees in 2007. In all, there were 78 responses to the question: *"In your opinion, what might be the barriers of acquiring a wood pellet heating system?"* These answers identified 80 different perceived barriers for evaluation. Three researchers classified this list using content analysis. The results of the article are summarized here, but because of the focus of the research overall, the description concentrates on Rogers' (2003) framework. Hence, what is the categorization of the perceived acquisition barriers of wood pellet heating systems according to characteristics of innovation?

Our results led to several interpretations. The high number of different perceived barriers (19) in the complexity category was to be expected in this study, since the question asked participants to address the perceived barriers to acquiring the wood pellet heating system. Utilizing both Christensen's (1997) and Rogers' (2003) frameworks, the researchers observed that most of the barriers (21) concern the price and relative advantage categories. The results are in conformity with definitions of the utilized categories.

In the final classification, no barriers were linked to either the trialability or observability categories. Lacking a trial might be typical of long-commitment investments such as residential heating systems. Furthermore, the results regarding Rogers' characteristics seem to be somewhat evolutionary, interestingly, since the number of barriers decreases from relative advantage to observability. The idea of evolutionary characteristics of innovation is consistent with Faiers et al. (2007).

Finally, the value of K-alpha was 0.84, indicating an almost perfect agreement between the evaluators (Landis & Koch 1977). In the case of Rogers' (2003) model, finally, the value of K-alpha rose to 0.75, indicating substantial agreement between evaluators. This reflected difficulties that the evaluators experienced in their assessments, as Rogers' (2003) framework of innovation characteristics was more complicated to utilize than Christensen's (1997) framework.

This exploratory empirical study provided insights into the perceived barriers to acquiring wood pellet heating technology. Utilizing Rogers' (2003) framework proved rather difficult in the context of these perceived barriers. In particular, the definition of relative advantage may involve a number of different issues; here, at least all four attributes of basis of competition are relevant. Finally, our insights into barriers to acquisition can help in identifying practical ways to promote the wood pellet heating system and how customers' perceived barriers could be overcome. However, in order to promote the system, future research into perceived acquisition criteria related to the wood pellet heating system is also needed.

3.4. Perceived criteria in the adoption decision

In the literature, five characteristics of innovation have traditionally been seen to affect the adoption decision (Rogers 2003). Researchers have also found that homeowners' mean values in rating heating systems include several factors (Mahapatra & Gustavsson 2008b, 2009); however, there is a limited focus when it comes to attributes influencing the decision to adopt the wood pellet heating system. Thus, this fourth article, originally named *"Characteristics of innovation in adopting a renewable residential energy system,"* continued the discussion in previous articles about acquiring factors in the context of renewable energy systems. In particular, this article investigated the perceived acquisition criteria influencing the decision to adopt wood pellet heating systems. Hence, for this research, the question is formulated as follows: What are the perceived adoption criteria for wood pellet heating systems and their categorization according the characteristics of innovation? The aim of the article was twofold: to perform a review of the literature on characteristics of innovation and to empirically investigate the categorization of perceived acquisition criteria related to wood pellet heating systems according to these characteristics of innovation.

The literature was reviewed for 1986 to 2008 to assess the extent to which Rogers' (2003) framework for characteristics of innovation was used in literature assessing adoption of innovations. The results of the literature review can be summarized as follows: Firstly, Rogers' *Diffusion of innovation* is cited widely; however, the search results show fluctuations in the characteristics of innovation publication counts. Secondly, not all the characteristics were mentioned in every selected publication. This might indicate that not all characteristics were considered useful or that the characteristics were not defined in the same way in all study contexts. References to trialability and observability, in particular, were less frequent than references to other characteristics of innovation. Interestingly, there were only two studies relating to energy and fuel. Therefore, it was possible to conclude that existing studies view the characteristics of innovation as applicable in various fields but, at the same time, do not use Roger's framework as whole in explaining adoption of innovations. This led the researchers to investigate empirically the perceived acquiring criteria that customers used in evaluating innovations, and how these might relate to Roger's framework.

In addition, the perceived criteria that were presented by customers as influencing the decision to acquire the wood pellet heating system were investigated, along with the categorization of the perceived criteria according to the characteristics of innovation. Customers' perceived criteria were collected through a survey (sample size N=154) of Finnish housing expo attendees in 2007. In all, there were 95 responses to the question: *"In your opinion, what are the most important selection*

criteria for acquiring the pellet heating system?" These answers gave 96 different perceived criteria for evaluation. Seven researchers classified this list using content analysis.

Summarizing the results of the content analysis, overall, the most straightforward characteristic was relative advantage. The results of content analysis indicated that only 22 of the 96 perceived criteria exhibited perfect agreement (100%) in our classification; 17 of these perceived criteria assessed relative advantage, and 5 assessed compatibility. In the compatibility category, interestingly, the most agreed upon perceived criteria were related to environmental issues.

For all classifiers, the K-alpha had a value of 0.2771, indicating only slight agreement (Landis & Koch 1977). Of 96 criteria, 11 were classified as belonging to four different categories, which indicated major disagreement between the classifiers. Therefore, a follow-up study was conducted in order to analyze the possible reasons for these 11 divergent classifications. Firstly, the observed complexity in the perceived criteria may have been caused by overlapping definitions of characteristics of innovation. Secondly, classifiers considered the definitions of particular perceived criteria to be ambiguous by classifiers. Thirdly, a general observation as to why a categorization might be difficult to classify is that a categorization might relate more to the characteristics of the macro-environment than to the characteristics of the actual innovation. The results of the follow-up study support the findings. For instance, the predominance of relative advantage supported the findings because all characteristics could be used to compare innovations with each other and relative advantage seemed to be the easiest characteristic to apply in such comparisons.

In conclusion, the purpose of this study was to address the characteristics of innovation; it contributed to the existing literature in two ways. Firstly, investigating the existing body of knowledge, the research highlighted the use of characteristics of innovation in current literature. The literature review showed that most of the findings of previous studies employed the characteristics of innovation but did not confirm the usability of Rogers' framework as whole. Secondly, the research empirically examined the perceived acquisition criteria for the wood pellet heating system, which were categorized according to the characteristics of innovation. The results demonstrated that relative advantage was the predominant characteristic influencing adoption of the wood pellet heating system.

3.5. Value for customer in the perceived criteria

The vast literature on value for customers has highlighted that perceived value for the customer has a motivating impact upon willingness to buy (Dodds, Monroe, & Grewal 1991; Sweeney, Soutar, & Johnson 1999; Zeithaml 1988). This fifth article, originally named *"Characteristics of value in green technology investments,"* continued the discussion of the previous article about categorization of perceived acquisition criteria according to characteristics of innovation. The previous article provided quantitative results on this categorization, thus here, the researchers attempted to analyze the results with a slightly more qualitative approach, particularly in terms of theoretical value from the customer's perspective.

To understand how perceptions are formed and adoption decisions are made, a number of existing theoretical perspectives on the characteristics of innovation and the value for customer should be combined. Thus, the purpose of this article was to address the issue of the categorization of

perceived acquiring criteria according to characteristics of innovation to analyze the value for customers in the wood pellet heating system context. For this research, the purpose led to our research question: What is the value for the customer in the context of the categorization of perceived acquisition criteria for wood pellet heating systems according to the characteristics of innovation?

The empirical data was collected, as described in the previous section, with a survey at the Finnish Housing Expo in 2007. The answers to the question, *"In your opinion, what are the most important selection criteria for acquiring the pellet heating system?,"* gave 96 different perceived criteria for evaluation. Seven researchers classified this list using content analysis. The results were analyzed in order to explain the results from the theoretical value for the customer perspective. The three analyses were presented as follows. 1) Perceived criteria was discussed as value characteristics; thus, customers may use the perceived criteria to judge the value of the characteristics of innovation and the decision to adopt a wood pellet heating system. 2) Analysis of the dominance of relative advantage explained, particularly, that the predominance of relative advantage in the categorization results is consistent with value for the customer as the source of an advantage in the competitive environment (Woodruff 1997) and is judged to be relativistic (Holbrook 1996; Walters & Lancaster 1999). 3) The purpose of the third analysis was to offer some notifications for suppliers, for instance, to promote demand by sharing information.

To summarize the results, customers identified different value attributes, and thus their perceived adoption criteria varied. The results indicated that value attributes could be perceived in relation to actual technology, additional services, or other macro-environmental factors. In addition, the results indicated that adoption criteria or value could be evaluated from both positive and negative perspectives; in other words, customers evaluate both the benefits and costs of adoption.

The analyses provided several recommendations for managers in promoting, for instance, long-term investments, to influence the adoption decision by increasing the value for customers. Moreover, the analyses indicated some usability of the characteristics of innovation as a framework, despite the conclusions of the previous article. Thus, this article demonstrated the qualitative nature of the results of categorization according to the characteristics of innovation. In conclusion, the researchers propose that the characteristics of the innovation framework could be applied in innovation management research to evaluate value for customers in the increasingly important areas of energy and bio-fuels. Hence, the use of a framework requires an understanding of both the framework and the definitions of the characteristics of innovation along with the framework and content analysis and an open mind when analyzing the results.

3.6. Summary of the articles

Here, an overall summary and the outcome of the articles are presented. Several findings were gained in answering the research questions that further shed light on the attributes influencing the decision to adopt wood pellet heating systems.

Innovation is not diffused unless customers decide to adopt an innovation. Traditionally, the innovation decision process has been divided into stages, from knowledge to persuasion and decision, and finally to implementation and confirmation. However, innovations can be adopted or

rejected (Rogers 2003), which leaves challenges for companies to understand customers' perceptions and decision to adopt an innovation. Additionally, communication is a central part of the diffusion of innovations (Rogers 2003), and publications are one way to share information.

An overview of the vast literature on the adoption of innovation showed that previous studies have reviewed different social settings and emphasized the incentive and preventive roles of the attributes in the adoption of innovation. In addition, many findings of previous studies employed the characteristics of innovation framework designed by Rogers (2003).

This research focused on the perceived acquiring factors, i.e., criteria and barriers, and the basic profile of the customers. The information was conducted with a survey method. More understanding of the perceived factors was gained with the categorization of the factors according to the characteristics of innovation defined by Rogers (2003) with the content method. The results of the categorization of the perceived criteria were further analyzed with the theoretical value for customer perspective, which provided more quantitative analysis and implications. Additionally, the assessing publication activity demonstrated the communication activity of the wood pellets and related technologies.

Our empirical results demonstrated that customers' gender influences perceived familiarity and knowledge regarding the decision to adopt wood pellet heating systems. Furthermore, age is a factor in the intention to select a new heating system. Women's perceived familiarity and knowledge were relatively low compared to men. This occurred despite the demonstration that the wood pellet heating system has gained a foothold in communications in several kinds of publications and that communication has increased during the observation period, especially in the 21st century.

Utilizing both Christensen (1997) and Rogers' (2003) frameworks, it was observed that most of the barriers concern price and relative advantage. Similarly, after categorization of the perceived acquiring criteria, relative advantage was the predominant characteristic influencing the decision to adopt wood pellet heating systems. Thus, relative advantage was highlighted regarding both perceived acquiring barriers and factors. Therefore, relative advantage has emphasized influence on the decision to adopt the wood pellet heating system.

Overall, the articles addressed the attributes influencing the decision to adopt wood pellet heating systems from the customer and innovation perspectives. Thus, the research developed Rogers' (2003) discussion and was related to the discussions of Mahapatra and Gustavsson (2008a, 2008b, 2009) and Faiers, Neame, and Cook (2007), with a particular concentration of attributes influencing the decision to adopt wood pellet heating systems.

Furthermore, the research provided some interpretations. In profiling customers with basic demographic attributes, age and gender, significant differences were found. After acknowledging the basic information about customers, deeper profiling of customers could be done in future studies.

Assessing the communication activity provides information about the number of publications in time, which further indicates the differences in communication activity during the studied period. However, the technology life cycle indicators (Watts & Porter 1997) were considered to indicate a

more exact development phase, and have presumed linearity, which leaves challenges for future research.

The variation in the categorization of the perceived acquiring factors indicated, first, a difference in perceived factors influencing the decision to adopt wood pellet heating systems. An adoption decision could be done with several bases, for instance, factors could be perceived in relation to actual technology, additional services, or other macro-environmental factors. This indicates that the characteristics of innovation that relate strongly to the innovation may not explain all persuasions influencing the decision to adopt an innovation. This is in line with the observed problem with usability issues in the characteristics of innovation as a framework. However, in analyzing the results of the categorization of the perceived acquiring criteria according to the characteristics of innovation with a qualitative method, for instance, with the value for customer perspective, more understanding could be achieved.

This research has, in addition, managerial implications in focusing on the promotion of innovation in a residential heating context based on the acknowledgement of differences between women and men, customers of different ages, and, further, customers' perceived familiarity and knowledge regarding the acquiring factors that influence adoption issues. This might support the targeting of the development and marketing of wood pellet heating systems, which might further increase the number of sales and decrease developing and marketing costs. Especially, in providing value for customers on a relative basis, wood pellet heating systems could be increasingly adopted; at least, customers have an option in deciding to adopt a renewable energy heating system. Thus, the outcome of this research is valuable for both the demand and supply sides of wood pellet heating. Understanding the demand-side factors of the decision to adopt an innovation might support the development of the supply side, which further supports, or provides an alternative for, customers, those who are willing to make the decision to adopt a residential heating system.

In conclusion, the existing body of knowledge regarding attributes influencing the decision to adopt an innovation was studied, and customers' perceptions were examined and further analyzed with the previous knowledge of literature on the adoption of innovation. In addition, background information and the utilized methods were reported. Furthermore, interpretations and implications for limitations were discussed. Accordingly, this research contributes to the literature as described in the following section.

4. CONCLUSIONS

The previous chapters were all geared toward giving evidence for the overall conclusions. Pulling the different aspects of the research together, conclusions, including the contribution of the research, discussion, assessment of the research, and suggestions are presented in this chapter.

4.1. Contribution of the research

Here, the contribution of this research is discussed. This research investigated attributes influencing the decision to adopt innovations in the residential heating system context. In this way, the research contributes to the existing adoption of innovation literature from the innovation and customer perspectives by identifying empirically examined attributes influencing the decision to adopt wood pellet heating systems. Concrete and context-dependent knowledge has its own value, since building predictive theories and universals is difficult in the study of human affairs (Flyvbjerg 2006).

Taking an overview of the existing body of knowledge, the research highlighted the use of adoption attributes in the current literature, thus contributing the discussion by Mahapatra and Gustavsson (2008a, 2008b) and one of the seminal works by Rogers (2003). The literature review showed that many of the findings of previous studies employed the adoption of innovation theoretical approach, including in a residential energy context (e.g., Mahapatra & Gustavsson 2009; Faiers, Neame, & Cook 2007), but left open the question of the attributes influencing the decision to adopt wood pellet heating systems. The question was also observed to be relevant from the practical and contextual points of view.

The evidence of findings should be logical or empirical (Whetten 1989). In this research, attributes influencing the decision to adopt wood pellet heating systems were empirically examined. The results showed that personal attributes influence issues related to the adoption of wood pellet heating systems. In particular, firstly, men had more perceived familiarity and knowledge than women regarding issues related to the adoption of wood pellet heating systems. Secondly, age influenced the intention to select a new heating system; the intention to do so was greater in respondents in the ages of 35-44 compared to the ages 25-34. Furthermore, the research demonstrated that information related to wood pellet and related technologies is communicated in several kinds of publications, and that communication has increased during the observation period, especially during the 21st century. Thus, the research contributes to the understanding of both researchers and managers in the field of residential heating by providing empirically examined findings for future research and practice.

In addition, in this research, the perceived acquisition factors, i.e., barriers and criteria, of the wood pellet heating system influencing the decision to adopt the system were further empirically examined. The factors were categorized according to Rogers' (2003) characteristics of innovation and the results were also analyzed from the perspective of theoretical value for customers (e.g., Woodall 2003). The categorization showed differences between characteristics of innovation influencing the decision to adopt a wood pellet heating system. In particular, the results demonstrated that relative advantage was the predominant characteristic influencing the decision to adopt wood pellet heating systems. In addition, the categorization of perceived criteria according to

characteristics of innovation indicated that value for customer was an important factor, and thus continuing discussion of value for customer conceptualized by (Woodall 2003). Focusing on multiple elements or perspectives of the theory added thoroughness to the discussion (Whetten 1989). Hence, the research contributes to the adoption of innovation literature by providing multiple findings analyzed by several theories in the context of a renewable residential heating system. These findings may be useful for future research.

In conclusion, this research explored attributes influencing the decision to adopt wood pellet heating systems. The results of the research have been published in five articles in peer-reviewed journals and given at conferences. Thus, taken to together, this research can be considered to further improvement in the management of innovation and technology research field.

4.2. Discussion

The motivation behind this research was an interest in studying attributes influencing the decision to adopt wood pellet heating systems from the customer and innovation perspectives. The main research question was divided into five research questions, as described below.

Q1) Do customers' personal attributes influence decision to adopt wood pellet heating systems?

Q2) How and in what sequence is information on wood pellet and related technologies communicated by different sources?

Q3) What is the categorization of the perceived barriers to acquiring wood pellet heating systems according to characteristics of innovation?

Q4) What are the perceived criteria for adopting wood pellet heating systems and their categorization according to the characteristics of innovation?

Q5) What is the value for the customer in the context of categorization of perceived acquisition criteria of wood pellet heating systems according to the characteristics of innovation?

The research questions and objectives led the process of the research. Several steps were taken to respond to these questions, as described in the section 1.3. The great amount of literature on adoption of innovation provided some answers to the questions, but did not confirm the attributes influencing decision to adopt wood pellet heating systems as a whole. The innovation perspective used here focused on the adoption of innovation theories, particularly diffusion of innovations, the innovation decision process, and characteristics of innovation. The customer perspective used here focused on the theories regarding adopter categories and value for customers. Subject matter from the customer perspective on adoption attributes focused firstly on personal attributes, i.e., age and gender, in relation to perceived familiarity and knowledge. This led to the second article, considering the communication activity related to wood pellet and related technologies. In addition, the customer perspective supported dissemination of the survey, which allowed for the study of perceived acquisition barriers and factors influencing the decision to adopt wood pellet heating systems. The results generated in relation to the research questions are discussed below.

From results regarding the first research question, it could be concluded that customers' gender influences on perceived familiarity and knowledge regarding the decision to adopt wood pellet heating systems, and that age affected intention to select a new heating system.

These differences indicated the influence of personal attributes in the decision to adopt wood pellet heating systems. This finding is consistent with the results of Mahapatra and Gustavsson (2008b, 2009), who showed a significant relationship between age of respondent and plan to install a new heating system in their baseline survey. In addition, the finding is in line with the argument that adopters of innovation differ from one another (Dickerson & Gentry 1983; Mahajan, Muller, & Srivastava 1990; Rogers 2003) and that different customers or customer segments will value different attributes, or the same attributes to different degrees, within the same product (LeBlanc & Nguyen 1999; Parasuraman 1997; Treacy & Wiersema 1993). However, it is noted that age has an influence in basic and innovative function usage, as well as intention to upgrade (Huh & Kim 2008). Hence, the results might be skewed in the sense that the results also reveal that customers in other age brackets are not inclined to select new heating systems.

The innovation decision process has traditionally been identified as beginning at the knowledge stage (Rogers 2003), and customers' knowledge can be subjective as well as objective (Selnes & Grønhaug 1986). The results regarding the first research question highlighted the importance of perceived familiarity and knowledge in relation to adopting wood pellet heating systems; this has managerial implications to promote the system. Previous research has found that, in the residential heating context, customers planning to install a new heating system gather information from the mass media and from interpersonal sources and change agents (Mahapatra & Gustavsson 2008a, 2008b, 2009). Because installers/vendors are the most important source of information in the residential heating system context (Mahapatra & Gustavsson 2009), the shared information could be targeted to installers/vendors and further to customers. However, on the other hand, customers might perceive the installers and vendor as subjective sources of information, when other sources of information, such as publications, are needed in the decision to adopt a residential heating system. The literature indicates that mass media channels are primarily knowledge creators; meanwhile, interpersonal networks are more important in influencing the decision to adopt or reject a product (Rogers 2003). Hence, to sell more wood pellet heating systems, promotion of the system in different channels and through networks is needed in order to improve the perceived knowledge of the product.

Communication channels might play different roles in the innovation decision process (Rogers 2003). Publications are one source for information that is relevant to the residential heating context (Mahapatra & Gustavsson 2008a). Thus, the assessment of publication activity regarding the second research question supported researcher's interest in studying perceived knowledge used in the decision to adopt wood pellet heating systems. Moreover, the researcher attempted to identify some technology life cycle indicators (Watts & Porter 1997) for evaluating, at least roughly, the development phase of the product through publication activity related to wood pellet heating systems. However, the technology life cycle indicators were supposed to point to a more exact phase, and a presumed linearity, which is in line with the criticism (Järvenpää & Mäkinen 2009).

Taken together, the discussion of the first and second research questions and some interpretations can be presented. In what sequence the technology is communicated in different publications indicates the interest regarding the topic. However, there are many other ways to share information than just through publications. In order to increase adoption of the innovation, the optimal combination of information-sharing channels and profiled customers might decrease the marketing costs and support the delivery of the message to the target markets. In addition, the delivered message might increase the adoption of innovation, which is in line with Rogers' (2003) work. Alternative communication channels and the delivered message leave topics for diffusion and marketing researchers, for instance, for discursive analysis of how information about the wood pellet heating system is communicated in the mass media for women or young adults.

Whether the respondent in the survey is also the decision maker in the process of wood pellet heating system adoption or not, is threefold. In the innovation decision process, the decision stage is when the customer engages in activities that lead to adopting or rejecting an innovation (Rogers 2003: 177). Respondents in the survey were active enough to visit the housing expo. Thus, first, the respondent could be seen also as the decision maker. However, because Rogers states that a social system is a set of interrelated units, the social system may affect innovation, as well as acting as a boundary for innovation diffusion (Rogers 2003: 1-38). Thus, second, the respondent could also be a partial decision maker, because she or he is a member of a unit; for instance, family members living in a house could be seen as a social system. However, the partial decision maker is still a decision maker; thus, in optional decisions, the customers making the adoption decision have almost complete responsibility for the decision (Rogers 2003: 29). However, third, in diffusion research, other roles are recognized: for instance, an opinion leader, which refers to an individual who influences other attitudes, or a change agent, which refers to an individual who influences customers' decisions to adopt an innovation by a change agency (Rogers 2003: 27). Hence, the research focused on residential customers and therefore assumed that customers can make optional innovation decisions. Thus, the respondents could be primarily seen as the decision makers in the decision to adopt or reject the wood pellet heating system; however, whether the respondent is the decision maker or not was not assessed here.

Next, research questions three to five (Q3-Q5) are discussed in together because they consider perceived acquisition factors, i.e., barriers and criteria. Content analysis was also adopted to categorize perceived acquisition barriers and criteria according to characteristics of innovation. However, using content analysis might be challenging, as discussed in the section 4.3. The variation in categorization indicated differences in categorizing perceived barriers and criteria according the characteristics of innovation influencing the decision to adopt wood pellet heating systems. One explanation for this might be that customers use different perceived factors, i.e., barriers and criteria, to judge and determine the value of adoption. On the other hand, existing studies viewed the characteristics of innovation as applicable in various fields, but at the same time did not conclude that Rogers' framework as a whole was applicable in explaining the attributes influencing the adoption decision.

The results indicated that perceived acquisition barriers and criteria influencing the decision to adopt wood pellet heating systems can be perceived in terms of the actual technology, additional services, or other macro-environmental factors. The same factors may be used for judging value for

the customer ex ante or ex post (Gorth & Dye 1999); however, customers may also use different criteria (Parasuraman 1997). In conclusion, perceived acquisition factors vary; thus, customers value different adoption attributes.

In addition, the results indicated that adoption criteria can be evaluated from both positive and negative perspectives. Categorizations of perceived barriers and criteria according to characteristics of innovation were somewhat in line with each other; for instance, most of the perceived criteria and barriers were found to concern relative advantage, thus supporting the categorization findings in the decision to adopt wood pellet heating systems. Thus, customers evaluate both the costs and benefits of adoption, which is consistent with Woodall (2003), Ravald and Grönroos (1996), and Bolton (1998).

In addition, the results demonstrate that relative advantage is a predominant characteristic, at least influencing the decision to adopt wood pellet heating systems. These results are consistent with those of Faiers et al. (2007), who found that the advantages and benefits of a product are the most important factors in deciding to buy the product. The results indicate that the relative advantage is clear, especially with monetary issues, since costs and profitableness can be used to compare the prices of heating systems against others, and relative advantage seems to be the easiest characteristic to apply in such comparisons. Placing monetary issues in the relative advantage category is in line with the idea that customers are influenced more by costs than by benefits, or more by loss than gain (Bolton 1998; Ravald & Grönroos 1996; Woodall 2003). In addition, the results showed that, at least from one classifier's perspective, 91 percent of perceived acquisition criteria assessed relative advantage. Thus, relative advantage as a predominant characteristic is consistent with the idea that value for customers is emphasized, intensified, or exposed in a competitive environment (Woodruff 1997) and is judged relativistically (Holbrook 1996) against other competing products (Walters & Lancaster 1999). Customers actively seek compensation; hence, where perception of risk increases (predicted sacrifice), customers seek enhanced benefits to compensate for this (Ostrom & Iacobucci 1995). The purpose of the incentives is to increase the degree of the relative advantage of the innovation (Rogers 2003: 236-239). Thus, in order to increase the degree of the relative advantage of the decision to adopt wood pellet heating systems, incentives could be used. This is in line with the contextual development in the global wood pellet heating system markets. In addition, climate change and financial crises may be examples of events that emphasize the relative advantages of innovation. Hence, customers might choose one heating system over another because they believe they will get a better value than they could expect from an alternative. Naturally, however, all characteristics of innovation could be used in a general comparison of innovations.

However, instead of making a rational adoption decision, customers may also adopt or reject an innovation in domestic energy use on the basis of an emotional response (Mahapatra & Gustavsson 2008b). In addition, the results indicate that instead of making a relative advantage–based adoption decision, customers may also adopt or reject wood pellet heating systems because of an ecological response. Interestingly, the results show that in the compatibility category, the most agreed upon criteria are related to environmental issues, which indicates the suitability of the use of wood pellet heating systems use in a social sense, and well as their suitability to the potential adopter's ecological values.

The result that all characteristics of innovation were not detected to the same degree in the research prompts interesting observations. One explanation, for why no factors were assigned to trialability category, in particular, lies in the definitions of characteristics of innovation. Another explanation may be that a customer's decision to adopt the wood pellet heating system is not easily revoked, since the replacement costs of such systems are relatively high. The finding is consistent with those of Labay and Kinnear (1981), who observed that trialability is not closely related to the adoption of solar-energy systems. However, customers are not able to reliably predict what they will value in the future (Huber et al. 1997; Woodruff 1997). Therefore, these results might be skewed in the sense that the current technological heating system solutions and adopter categories may serve to exclude, for instance, trialability, from the characteristics influencing the decision to adopt wood pellet heating systems. A final explanation might be that the five characteristics conceptualized by Rogers (2003) may not be suited to the analysis of the types of attributes influencing the decision to adopt wood pellet heating systems. However, the term value for the customer captures a range of associated and existing concepts, which imply a similar idea of the existence of property that is perceived or experienced by a customer (Woodall 2003). Thus, although the research did not confirm the use of the characteristics of innovation framework as a whole, characteristics of innovation could be applicable for analyses; this is demonstrated in article 5. The conclusion is rather anecdotal by nature; however, it also leads the way for future research.

The research demonstrated that the characteristics of innovation are not an absolute measure in customers' decisions to adopt residential heating systems but, on the other hand, provided analyzed information about the perceived acquiring factors for possible interpretations to discuss as follows.

The empirical investigations in this research showed that the decision to adopt an innovation is not straightforward. The research indicated that the adoption attributes of innovation differ depending on the customers' viewpoints and perhaps also time and context. This leads to the conclusion that customers and their perceptions are rather unique, but, on the other hand, have similarities.

The research results indicated that customers make the decision to adopt the wood pellet heating system by emphasizing the relative advantage. Regarding relative advantage, there are different elements to value; however, the results highlighted financial issues. The two perspectives, customer and innovation, were presented in this research. The combination fulfills the understanding about perceptions and adoption attributes. Thus, for instance, if ecological values are considered to be an increasing megatrend in the future, the combination of relative advantage and ecology issues might provide a relative advantage for wood pellet heating systems in residential heating markets.

However, customers and their perceptions might change in time, for instance, because of the relative differences between the alternatives. Hence, even full understanding and responding to the desired value for customers might not guarantee the increased diffusion of the innovation. First of all, an undesired value may exist, which require companies' resources or, second, an undelivered value may exist, which might have a negative influence on the decision to adopt an innovation. Thus, research and development need to continue to gain more understanding of the demand side and further to develop the heating systems and supply side in order to compete against the competition in the residential heating markets. In the adoption decision research, both the demand and supply sides have an influence (e.g., Tidd & Bessant 2009). In this research, the demand-side

factors were the focus. However, in order to increase the adoption of wood pellet heating systems, more understanding of supply-side factors would complete the research on the adoption of wood pellet heating system, for instance, a study of the supply chain of the wood pellet heating system from the new product developer and manufacturers until the implementation and demolishing of the system. In addition, diffusion research easily assumes that the technical solutions do not change. However, technical evolution and improvements might have a remarkable influence on the decision to adopt an innovation.

By answering the research questions, this research critically considered discussions about the adoption of an innovation. The synthesis from the research results indicated that this research shed light on certain attributes influencing the decision to adopt wood pellet heating systems, thus contributing to the adoption of innovation research field in the context of a residential heating system. Different contexts, alternative specifications, methods, or theoretical perspectives might offer new knowledge or other insights and complete the understanding of attributes influencing the decision to adopt wood pellet heating systems. Hence, the research results are open to accept more sensitive idea generation for future studies and opportunities for both incremental theory and practical development.

4.3. Assessment of the research

Neither the "best" strategy or set of choices for a research problem, setting and available set of resources, nor correct set of methodological choices will necessarily guarantee success in research (McGrath, Martin, & Kulka 1982); thus, an assessment of the research is needed. The main criteria for assessing scientific research can be summarized, which are that proposed claims must hold truth, and statements must have general value (Salonen 2001: 51). In order to assess the research, the dimensions of evaluation involve, for instance, a general assessment, relevance, validity, reliability, and generalizability. In evaluating this research, below, the validity and reliability of the research are focused on, including a discussion of the limitations of the research.

4.3.1. Validity

Validity is broadly defined as whether the researcher is studying the question or phenomenon that he/she is attempting to elucidate (McKinnon 1988). Validity refers to whether or not indicator or set of indicators devised to gauge a concept really measures the concept (Bryman & Bell 2007: 165). Several types of validity are recognized in the literature. Internal validity, external validity, statistical validity, construct validity, convergent validity, discriminant validity, cross-validation, face validity, concurrent validity, content validity, criterion validity, predictive validity, and empirical validity are types of validity; however, some of these types of validity overlap or are used to denote subtypes of the main type of validity (Carmines & Woods 2005b). The following discussion covers the internal and external types of validity and measurement in validity assessment, which are close to the limitations and bias in this research.

Internal validity refers to the robustness of the relationship of a concept to another internal to the research question under study (McDonald 2005). The internal validity in this research increased with the utility of categorization according to the characteristics of innovation in three of the five

articles in the literature review. In addition, internal validity increased in focusing on the wood pellet heating system in every article. Thus, the internal validity is rather good in this research.

External validity concerns generalization across time, settings, and individuals (Scandura & Williams 2000); results should be generalizable beyond the specific research context (Bryman & Bell 2007: 42). In that sense, no grand theory can be built based on this research alone. Most of the findings are supported by previous studies, increasing confidence in the findings and further improving the external validity of the research. Thus, the research findings could be applied, as suggested in the last section of the research.

Validity concerns whether a measure actually measures the concept that the measure is being used to represent. Measurement focuses on the representation of abstract concepts by empirical indicators (Carmines & Woods 2005b). Hence, the validity of this research is evaluated below in terms of the theoretical, empirical, and process elements of the research.

First, the abstract concepts used in the theories about the adoption of innovation were evaluated. The literature review in this research highlights the use of theoretical frameworks that should improve the validity of the research. However, theories are always incomplete because they deal with a subset of the variables that exist in the real world (Calder, Phillips, & Tybout 1981), influencing the validity of the research. Tidd and Bessant (2009) have identified some shortcomings of research and practice in diffusion research. For instance, diffusion research has used adoption as a dependent variable, meaning the decision to use the innovation, rather than implementation itself, meaning the consequences of the innovation. This is the case in this research.

The diffusion research literature acknowledges that it suffers from a pro-innovation bias, in which it is assumed that an innovation should be adopted as rapidly as possible by all members of a social system (Rogers 2003). Criticisms of diffusion research concern the pro-innovation bias, the individual-blame bias, the recall problem, and the issue of equality (Rogers 2003: 105-135). *The pro-innovation bias* means that the innovation should be adopted by all members of a social system and diffused more rapidly and an innovation should be neither rejected nor re-invented (Rogers 2003: 106-118). This research has acknowledged the re-invention in the collection of the data, which does not restrict the sample based on the respondents' current heating system. In addition, the rejection is acknowledged, especially in studying the perceived barriers in article 3. The fact that the practical requirements for increasing the number of wood pellet heating systems adopted might cause pro-innovation bias for the research. However, the research for understanding the motivations or perceptions for adopting an innovation might help in avoiding pro-innovation bias (Rogers 2003: 115-116).

The source of the starting point for this research causes the pro-innovation bias and guides the outline of the research. Promotion of the innovation viewpoint has been accepted by diffusion researchers (Rogers 2003: 110) *The individual-blame bias* refers to the tendency to hold a customer responsible for the problems. The opposite is *the system-blame bias*, which refers to the tendency to excuse the system for being responsible for the problems. (Rogers 2003: 118-119) In order to overcome the individual-blame bias, diffusion researchers could seek alternatives to using customers as the sole units of analysis, for instance, *communication network analysis*, which refers to a method for identifying the communication structure. (Rogers 2003: 125-126) In article 2 the

communication activity of wood pellet heating systems in publications, which could be seen as an alternative communication analysis, where there are no interlocking personal networks, i.e., customers do not interact with each other, was studied. Moreover, potential adopters and rejectors should be taken into account as a way to overcome the individual-blame bias (Rogers 2003: 125), which has been used in this research in collecting the data. *The recall problem* refers to the inaccuracies when respondents are asked to remember the time when they adopted a new idea. This research does not suffer from the recall problem, because of the *ex ante* approach for the decision to adopt the wood pellet heating system in conducting the survey. *The issue of the equality*, meaning socioeconomic gaps, such as higher- and lower socioeconomic status (Rogers 2003: 130-135) and respondents' annual income, was not assessed here.

Second, in evaluating the validity of empirical focus, the empirical focus is on observable responses such as answers on a questionnaire (Carmines & Woods 2005b). Methods that are used in cross-sectional research might disrupt the natural habitat of those studied (Bryman & Bell 2007: 58), and therefore influence the validity of the research. In addition, customer research is criticized because respondents might say what they think the researcher wants to hear (Shimp, Hyatt, & Snyder 1991). However, one of the strengths of this research is that the respondents freely reported the perceived acquisition factors in answering the questionnaire; this should improve the validity of the research. On the other hand, respondents may not adopt any residential heating system; this would impair the causal findings and influence the validity of the research. However, in a cross-sectional research design, it is typical that associations rather than causal findings are produced (Bryman & Bell 2007: 58).

Third, during the process of measurement, researchers can evaluate the empirical applicability of theories (Carmines & Woods 2005b). The research employed content analysis that can be briefly defined as a systematic, objective, quantitative approach to analyzing message characteristics (Bryman & Bell 2007: 302). The utilization of content analysis has certain limitations. Firstly, the classifier might not be knowledgeable enough in terms of either the characteristic of innovation theory or the wood pellet heating system. Secondly, Rogers' framework might be too complex to use in the categorization of acquisition factors, because the characteristics of innovation concentrate on innovations rather than, for instance, macro-adoption factors. Thirdly, as the results showed, one perceived acquisition factor could be classified in several different categories, decreasing the validity of the characteristics of innovation as a framework. However, in theoretically derived classificatory research, typologies are expected to enumerate theoretically valid ideal types of factors that may not be found empirically in the purest and ideal form (Bailey 1994: 17). This is in contrast to taxonomic classificatory research, which is driven or derived empirically. In addition, the possibility that some perceived factors not be classified as any of the characteristics of innovation has not been tested in this research; this may have influenced the results. In addition, the strength of the content analysis is that all classifiers were members of the same research centre, and thus had some interest in innovation management theories. In conclusion, the content analysis approach influences the validity of the research.

Overall, the validity of the research is not optimal, but its limitations are typical in diffusion and cross-sectional researches. Also, replicability is present in cross-sectional research to the degree that the researchers have provided descriptions of the research procedures (Bryman & Bell 2007, p. 58).

Descriptions of research procedures are evaluated in peer-reviewed research articles; acceptance of the articles in various outlets indicates that the descriptions are replicable, in turn confirming the validity of the research as a whole.

4.3.2. Reliability

Reliability is broadly defined as whether the researcher is studying data which can be relied upon (McKinnon 1988). Reliability refers to the proportion of the observed score variance due to the latent true score variable (Alwin 2005: 351). In other words, reliability refers to the extent to which the same results on repeated trials are yielded from an experiment, test, or any measuring procedure (Carmines & Woods 2005b: 933). Measurement is fundamental for science; however, measurement might be challenging in the process of linking abstract concepts to empirical indicators. Because, for instance, attitudes, values, emotions, or psychological states reflect variables that are difficult to define and observe directly. (Alwin 2005: 351; Carmines & Woods 2005a: 361) Stability, internal reliability, and inter-observer consistency are three prominent factors in measuring reliability (Bryman & Bell 2007, p. 163). Whether a measure is stable over time can be tested with resurveys. Reliability refers to the consistency of measuring a concept. Here, it relates to the overall stability or dependability of the research results (Alwin 2005). Reliability is a necessary condition for validity, although virtually all social science data might have measurement error (McDonald 2005). Here, the overall reliability of the research is evaluated with respect to the limitations of the research.

In terms of the literature review, one limitation is the selected search terms. The search terms might have excluded other potentially related publications that did not contain this exact terminology. The difference could be explained by modified forms of terms or using different terminology. The selected databases are limited, for instance in giving access to limited search years, although the best databases were selected for the present purposes. This limitation could be improved by adding some sources not included in the databases or finding a database with more coverage. In addition, counts do not describe the quality of the publications. Therefore, it is possible that certain seminal works were not included. This limitation could be overcome by adding sources not included in the databases or finding a database with more coverage. Furthermore, there has certainly been research that was not published in English. The limitations impair the reliability of the results. However, data collections of the literature are described in details in articles 2 and 4, improving the replicability of the research and thus increasing the reliability of the results.

The survey data might be biased by the fact that the survey was conducted at an exhibition, in a single country in 2007, thus restricting the generalizability and reliability of the results. In addition, the results might have been influenced by the fact that the respondents were able to both view a working wood pellet heating system in the Housing Expo before answering the questionnaire and speak with the researcher or experts showing the wood pellet heating system. However, despite these limitations, the group of Housing Expo visitors forming the empirical sample was likely to be interested in domestic issues. In addition, the research was restricted to a limited number of respondents; however, for content analysis, the number of responses is fairly good. A larger and more heterogeneous sample might have given more specific information that would affirm the reliability of the results.

The collected survey data included only unique perceived acquisition barriers and criteria, and were populated as a primary data set. Because the freely written answers included a different number of factors per respondent, all unique factors were treated equally in this study. The research is limited in the sense that the number of factors that are the same across respondents is not measured. However, different factors might be only slightly different. In other words, perceived factors could be similar or almost the same across respondents. This, however, does not seem to be a problem in the research. Because the list is not condensed, the results should improve the reliability of the research. Furthermore, the statistical testing of data should influence to the reliability of the research.

To assess the reliability of the categorizations, we used Krippendorff's alpha (K-alpha) technique to improve the internal reliability of the research. This described the extent to which independent classifiers evaluate each item and reach the same conclusion (Krippendorff 2004; Lombard, Snyder-Duch, & Bracken 2002). K-alpha indicated the extent to which the different classifiers tend to ascribe the same factor to the same category. K-alpha values in this research indicated only slight and substantial agreement between the classifiers, which in turn impairs the internal reliability of the research. The alpha is usually higher when there are fewer categories (Sim & Wright 2005), whereas smaller samples could result in greater differences and a lower alpha (Lombard, Snyder-Duch, & Bracken 2004).

Overall, research can be viewed as a series of interlocking choices, in which researchers try to maximize conflicting desiderate, often simultaneously (McGrath, Martin, & Kulka 1982). As a whole, the reliability of the research is fairly good. The contribution of the research rests on five articles that have been published or accepted for publication in international journals and conferences proceedings. Hence, the articles have all been peer reviewed, which attests to their level of quality. This in turn reflects the reliability of the results and, further, the overall validity of the research.

4.4. Suggestions

The limitations described above reveal avenues for the future research. In addition, the research design, questions, and targets, along with other choices made during the research, have led the research to the current state, which can illuminate some suggestions for managerial practice, for energy policy and future research, as discussed below.

4.4.1. For managerial practice

Initially, the driving force for the research was the practical interest in understanding the adoption of wood pellet heating systems, and therefore studying what factors influences their adoption decisions. However, this has also revealed managerial implications of the research.

Adopter categories may represent market segments that many companies are eager to identify, profile, and influence (Goldsmith & Flyn 1992; Rogers 2003). In a managerial sense, the results of the first research question indicated that studying customers' personal attributes, such as age and gender, might demonstrate differences between customer segments that influence the decision to adopt residential heating systems, and particularly wood pellet heating systems. This is in line with

the idea that demographics can be useful in profiling environmentally conscious customers (Diamantopoulos et al. 2003) and advertising (Shrum, McCarty, & Lowrey 1995). Successful sales to different adopter categories may provide important feedback to the company. Therefore, an intimate understanding of customer adoption attributes might be crucial for firms developing innovative heating systems and associated offerings.

Since wood pellet heating systems are one option for heating solutions, the wood pellet system seems to have gained a foothold in different kinds of publications, if assessed through attention and visibility gained. This is important to notice when communicating about new heating systems, both for potential developers and other supply-side stakeholders, and also for the demand side, in order to promote education and aid the diffusion process. The research results should be incorporated, for instance, in the marketing of new heating systems, to ensure that customers have access to published information.

Customers update value for the customer beliefs in relation to a specific product/brand/supplier through sequential buying activity (Bolton 1998). The presence —or nature— of value for the customer in a product cannot be assumed by the supplier; value for the customer is perceived by the customer (Butz & Goodstein 1996; Woodruff 1997), or exists mainly on the customer's terms. Rational buyers seek out best value for the customer (Slater & Narver 1994). Therefore, it is crucial for managers to inform potential customers and use the selected marketing channels to reach them. Thus, in order to promote demand for residential heating systems, and particularly wood pellet heating systems, information sharing channels to reach customers should take a wide range of sources, for instance, different social actors and organizations (Lappalainen 2007), installers or media (Mahapatra & Gustavsson 2008a, 2008b, 2009). In conclusion, instant two-way communication may become a managerial advantage for companies.

However, value for the customer can be perceived consciously, unconsciously, or pre-consciously. Customers determine or perceive value as an aggregate of weighted variables (Gorth & Dye 1999), or "value proposition." Therefore, the perceived criteria in acquiring wood pellet heating systems may be relative. Each customer has his/her own value model based upon his/her needs and desires (Ravald & Grönroos 1996), demographics or characteristics (Bolton & Drew 1991), and financial resources (Bolton & Drew 1991; Ravald & Grönroos 1996; Zeithaml 1988). Therefore, from a managerial perspective it may be difficult to evaluate, for instance, how easy or difficult the system is to use. However, value for the customers is delivered more effectively by reducing sacrifice than by increasing benefits (Grönroos 1997; Sweeney, Soutar, & Johnson 1999); therefore, if customers perceive ease of use as an adoption criterion, then decreasing the complexity may result in a competitive advantage for the company.

From a managerial perspective, the results also mean that adoption attributes, particularly customer resistance to innovations, may constitute a problem for the wood pellet heating market. In order to overcome customer resistance (Kleijnen, Lee, & Wetzels 2009), marketing strategies could include, for instance, customer education, using change agents (Rogers 2003), understanding and respecting traditions, or borrowing a good concept or creating a unique concept. Integrating environmental, cost, and customer valuation during the product design process, for example, might increase product value (Bovea & Vidal 2004).

The decision to adopt a residential heating system, however, does not have value for manufacturers until the customers' decisions to adopt are not completed. As the starting point for this research, there was practical interest in increasing the adoption of wood pellet heating systems for manufacturers, but in addition, in the global sense, the need for renewable energy technologies has been globally acknowledged. Hence, this research demonstrated the adoption attributes from the customers' perspective. Accordingly, during the innovation decision process, relative advantage as an emphasized characteristic of innovation should be provided for customers in order to increase the value for customers and increase the number of heating systems sold. However, the practical value of this research is not completed until the wood pellet heating system manufacturers and other renewable energy technology companies apply the knowledge gained from this research to their practices.

Finally, value for customers has managerial implications regarding strategic issues. Usually, value for customers is maximized where the product is of the highest quality, offered at the lowest price (Dodds 1999), and supported by the best service quality. Based on the research results, guidelines are proposed for managerial decision making with regard to the customers' decision to adopt residential heating systems. Information on the technological solution, its usage, advantages, and overall economic and social aspects needs to be disseminated in order to market a solution successfully. In particular, firms should prioritize communicating the relative advantages of the residential heating system over other strategies such as offering customers the chance to try the system. In addition, compatibility with the expectations of the market, such as ecological and domestic resource utilization, should be used to inform potential customers of the benefits of the technology over the alternatives. In conclusion, as value for the customer increases, so does value for the company.

4.4.2. For energy policy

Climate change is a global concern. Thus, in order to face the challenges posed by the EU, legislation and national support schemes for bioenergy technologies are needed.

In the current announcement (January 15th, 2010) by the minister of employment and the economy of Finland, Mr. Pekkarinen stated that the EU should give more financial support especially for the development of wood-based biofuel technology (Pekkarinen 2010) thus should provided also for the wood pellet heating. This is in line with the publications of the European Commission, for instance, the EU Biomass Action Plan, which is designed to increase the use of energy from forestry, agriculture, and waste materials in the heating, electricity, and transport sectors (Aebiom 2007). In addition, in the heating from renewable energy context, European legislation affects the residential heating markets. For instance, directive 2002/91/EC on the energy performance building involves measures regarding the energy performance in buildings (Aebiom 2007). Hence, the energy policy concentrates on increasing the utility of biofuel and decreasing energy consumption. However, while the supply-side factors of renewable energy are being developed, the demand-side factors should acknowledged in more detail, at least in Finland, as demonstrated in this research.

Wood pellets are mainly used from the residue of the wood industry. However, the activity of the wood industry set limits on the amount of residue available. In facing these challenges, the Finnish

forest industry might further affect the production of wood pellets. However, from the sustainable perspective, instead of exporting wood pellets, increasing the local use of wood pellets would decrease the amount of greenhouse gases produced during transportation, which would make the wood pellets even more environmental friendly.

The results of this research showed that the relative advantage, especially regarding financial issues, is a key attribute in the decision to adopt a biofuel for energy, at least in the residential heating context. The incentives may have several forms in increasing the relative advantage (Rogers 2003: 236-239) Thus, financial support, as given in various European countries, especially in Sweden, for adopting biofuel energy, could provide a relative advantage for biofuel-based heating systems compared to alternatives. The subsidies could further increase the adoption of renewable energy technologies, at least in the case of the wood pellet heating system.

The energy policy is not easy, because of the complexity of the varied national interests regarding energy, environment, and economic concerns. The contextual political factors attempt to change the behavior of people and companies. The change in behavior was not studied here. The research hardly indicates how policies should change. Thus, these are suggestions based on the literature and research results. The suggestions could be validated in future studies. Thus, more research is needed in order to state the urgent actions to be taken to avoid climate change.

4.4.3. For future research

Due to the exploratory nature of the research, the results pave the way for a number of possible future research avenues. The most central ones are discussed below.

First of all, further qualitative research on the content of the published articles can lead to more detailed analysis of the attributes influencing the decision to adopt wood pellet heating systems. For instance, the categorization of literature according to different industries or technologies and content analyses of publications can reveal a more detailed analysis of wood pellet heating systems' current status and future prospects.

The assumption behind innovation theory is that an individual or group can make a decision based on subjective knowledge and adoption attributes (Rogers 2003). Thus, psychological perspectives were closely related to but beyond the scope of this research. Theory of choice (Nassehi 2004), needs and wants (Ortt 1998), or Maslow's hierarchy (Maslow 1954) might play different roles in the innovation decision process, and are also linked to the characteristics of innovation. Neither prior condition was examined here. Because a wood pellet heating system is a rather big investment compared to, for instance, piece of bread, the adoption decision as an instantaneous act was not assessed in the research. Neither were adopter categories as ideal types (Rogers 2003) assessed, because of the concentration on the basic adopter categorization. In addition, the innovation decision stages after the decision, i.e., implementation and confirmation (Rogers 2003), were not considered in this research. Such issues show avenues for future research.

Utilizing characteristics of innovation was the central part of the thesis because of the targets of the research. However, the research neither attempted to generate nor redefine the characteristics of innovation; rather, it assessed the characteristics of innovation defined by Rogers (2003) as a "tool"

for categorizing perceived acquisition factors. Therefore, other characteristics, such as perceived risk and communicability, were not used in this research. Therefore, characteristics of innovation could be generated and redefined in future studies. In addition, the stepwise process of characteristics of innovations (Faiers, Neame, & Cook 2007) was not tested here in relation to customers, although it relates closely to the innovation decision process theory.

The intention in this research was not to construct a new framework for analyzing the perceived acquiring factors, but rather to examine the adoption attributes influencing decision to adopt wood pellet heating systems. In this research, the perceived acquisition factors were treated equally; therefore, future research could provide an initial classification of the factors that are synonymous with each other, followed by a triangular content analysis. Several iterations of content analysis might lead to classifiers' formulating their own categorization of perceived acquisition factors. However, the entire categorization should be tested using other data to verify it.

This research considered what influences the decision to adopt wood pellet heating systems, particularly focusing on the demand side of the adoption of an innovation, from the customer and innovation perspectives. Electricity production and consumption are beyond the scope of the research, because this research focuses on renewable residential heating, particularly wood pellet heating. This research focused on respondents who were individuals who decided to adopt or reject the wood pellet heating system independently, although the adoption decision might be influenced by community-related factors. This is consistent with the idea that one type of an innovation decision is the optional innovation decision (Rogers 2003: 25). However, the diffusion of innovation research has studied the demand and supply sides (Tidd & Bessant 2009). Future research could focus more on the supply side, particularly from energy policy perspectives in order to contribute to the inducement policy of bioenergy technologies.

The survey data was conducted at the one point at which data was gathered; thus, the research did not compare data from customers at several points in time during the diffusion process. Hence, the research did not consider the evolution of the wood pellet system as a technical system. Updated data could be collected with a new survey. For instance, the characteristics of innovation framework could be utilized in discussing the decision to adopt wood pellet heating systems in nonresidential houses or with other renewable long-term systems, for instance, other residential heating systems, in order to apply a comparative research approach. However, the challenge would be the complexity of comparativeness of the studies. In addition, from a reviewer's perspective, it is preferable to investigate qualitative changes in a theory rather than mere quantitative expansions (Whetten 1989).

Further research is also needed to contribute to the understanding of end-user adoption of long-term investments and energy technologies based on renewable energy sources. For instance, the decision maker could be studied by interviewing actual wood pellet heating system users in future studies. Finally, in order to increase the wider applicability of the results, a codebook detailing attributes influencing decision to adopt wood pellet heating systems could be written up for managers in order to guide them competitively in the residential heating market.

The objective of this thesis was to study the adoption of innovation in the renewable residential heating context, particularly in terms of what influences the decision to adopt wood pellet heating systems. Implications were specified, and suggestions for future studies have been indicated by this

research. Ultimately, much further research is needed to gain a more complete understanding of adoption of innovations. Finally, as a conclusion, the research needs to be continued in order to increase our knowledge.

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