USE OF ICT FOR ENERGY EFFICIENCY IN TURKISH CONSUMER ELECTRONICS SECTOR

SEÇKİN TÜRKCAN

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Prof. Dr. Meliha Altunışık
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science

Assoc. Prof. Dr. Erkan Erdil
Head of Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

Assoc. Prof. Dr. Erkan Erdil
Supervisor

Examining Committee Members,

Assoc. Prof. Dr. Erkan Erdil	(METU, ECON)	
Assoc. Prof. Dr. Teoman Pamukçu	(METU, STPS)	
Prof. Dr. Ülkü Yetiş	(METU, ENVE)	

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last name: Seçkin Türkcan

Signature :

ABSTRACT

USE OF ICT FOR ENERGY EFFICIENCY IN TURKISH CONSUMER ELECTRONICS SECTOR

Türkcan, Seçkin
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Development and enhancements in Information and Communication Technologies (ICTs) is following a high level trend promising many opportunities to the economy, environment and society. Utilizing ICTs to enable improvements in the field of energy efficiency is becoming a very hot topic across the globe in this context. In this study both the enabling role of the ICTs for ensuring energy efficiency and the carbon footprint of ICTs considering also the rebound effects was analyzed as a case study for Turkish consumer electronics sector. Desktop research and in depth interviews with representatives of the sector, aimed at assessing current situation and trends in the field, provided a basis for a qualitative analysis. In our assessment main focus was put on the enabling role of ICT in achieving energy efficiency gains and; thus, we intend to explore whether utilization of ICTs can help improving energy efficiency in consumer electronics sector in Turkey. Results of the analysis showed that there is a limited inclusion of ICT directly enabling energy efficiency in the sector. Moreover, there is a lack of awareness on the concept of ICT for energy efficiency concept in the sector. Discussion of the results was followed by policy recommendations for the enabling role of ICTs for achieving energy efficiency targets in Turkey. We argue that, by increasing the awareness on the topics, utilizing the potential strength of R&D capacities of the firms and deployment of links between the sector and global context on the ICT for energy efficiency, ICT can help improving energy efficiency in Turkish consumer electronics sector.

Keywords: ICT, Energy Efficiency, Turkish Consumer Electronics Sector

ÖZ

ENERJİ VERİMLİLİĞİ İÇİN BİLİŞİM VE İLETİŞİM TEKNOLOJİLERİ 'NİN TÜRK TÜKETİCİ ELEKTRONİĞİ SEKTÖRÜ 'NDE KULLANILMASI

Türkcan, Seçkin
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Bilişim ve İletişim Teknolojilerindeki (BİT) gelişmeler ve ilerlemeler ekonomiye, çevreye ve topluma birçok fırsat sunan yüksek bir trend izlemektedir. Bu bağlamda, BİT lerin enerji verimliliği alanındaki gelişmeler için kullanımı dünya genelinde çok önem verilen bir konu haline gelmeye başlamıştır. Çalışmamızda, BİT lerin enerji verimliliği sağlayan rolü ile sekme etkilerini de göz önüne alarak BIT lerin karbon ayak izleri, Türkiye 'deki Tüketici Elektroniği Sektöründe bir saha çalışması için incelenmiştir. Masa başı çalışmalar ve sektör temsilcileri ile yapılan derinlemesine mülakatlar nitel bir analiz için temel oluşturmuştur Değerlendirmemizde, BIT'lerin enerji verimliliği hedeflerini sağlamasındaki rolü esas alınmıştır. Böylece, BIT'lerin Türk tüketici elektroniği sektöründe enerji verimliliği sağlanmasındaki katkısını araştırmak üzere çalışmamızı tasarladık. Analiz sonuçları sektörde BIT uygulamalarının doğrudan enerji verimliliği için kullanımının oldukça kısıtlı yer aldığını göstermektedir. Ayrıca konu üzerinde bilgi ve farkındalığın çok düşük seviyelerde olduğu tespit edilmiştir. Sonuçların değerlendirilmesi, BİT 'lerin Türkiye nin enerji verimliliği hedeflerine ulaşmasındaki rolü için politika önerileri tasarlanmıştır. Eğer konu üzerinde bilgi ve farkındalık seviyeleri yükseltilip, firmaların araştırma geliştirme kapasiteleri bu konuda yönlendirilir ve sektör ile konu üzerindeki uluslararası yapılar arasında sürekli ve güncel iletişim kurulduğu takdirde, BIT'lerin Türk tüketici elektroniği sektöründe enerji verimliliğine katkı sağlayabileceği yaptığımız çalışma ile görülmektedir.

Anahtar Kelimeler: Bilişim ve İletişim Teknolojileri, Enerji Verimliliği, Türk
Tüketici Elektroniği Sektörü

To My Parents

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CHAPTER 1

INTRODUCTION

Sustainability, efficiency, greening of systems and cleaner production are among the most popular concepts of todays rapidly growing economy and sophisticated society. In the goal of minimizing the adverse effects of human activity on the environment, these terms often intended to define a new approach to current modes of production and consumer behaviour. Despite the fact that there are controversial debates on the validity of these concepts, it is a strategic path to put efforts through research and development on these topics considering the huge potential that they have.

Traditionally, problem solving has an approach that it serves for the instant visible solutions with every effort to achieve the required needs without considering the consequences of the action. This approach basically transforms the problem in to another one rather than solving it. For instance, installing a wastewater treatment plant to a pollution source only transforms the pollutants from one state to another. The system is limited to purification of water stream up to a standard but transferring the pollution stream into another medium. This short-term effective endeavour has its validity for certain situations; however, when we are dealing with globally complicated issues like sustainability, efficiency and pollution it is by definition that we need a pro-active way of thinking. Keeping in mind this philosophy in problem solving, when we study current sustainability and environmental issues, the complexity of the situation alarms for a departure from traditional approaches and requires new ways of thinking.

To illustrate, the concept of global warming is among the hot topics for research and the complexity is evident by itself. The most recent results by climate scientists are alarming as the accumulation of greenhouse gases (GHG) in the atmosphere is growing faster than originally predicted (Webb, 2008). However, this is not universally accepted, according to King and Walker (2008) and Hansen et al. (2008). Evidence from Mittelstaedt (2007) and IPPC (2007) backs up the idea that anthropogenic effects are not highly significant than the natural systems which accelerates the climate change. Debate goes on with Stern Review (2006) that the results indicate that ineffective struggle with climate issues could cause irreversible economic disruption like other issues causing economic depression. Regarding this view one sided, end-of-pipe manner is obviously deviates from converging to a solution. The debate may remain; however, the need for finding a way to sustain human activity and transforming to an efficient, low carbon economy is crucial.

To this end technological innovation and environmental issues should converge through a harmonizing dissolution by the key role of energy efficiency. Depending on technological enhancements, Information and Communication Technologies (ICT) should provide convenient means to tackle efficiency issues since they are among the main drivers of the 21st century. Besides, sophisticated capacity of ICT and highly penetration to our social institutional and organizational structures puts ICT to a focal point with its strategic advantages to achieve sustainable development function (Alakseson, 2003).

Our attempt possesses the view of enabling role of ICT in energy efficiency as well as briefly discussing the negative impacts in assessing the situation for Turkish Consumer Electronics sector as a case study. We are searching for current inclusion of ICT that utilized specifically for energy efficiency issues and the level of awareness across the sector on the topic. The issue is important hence European Union is taking serious actions in order to formulate this concept and to put it at a focal point in energy efficiency achievements. Regarding this view Turkey, on the edge of integration process to the union, should seek possibilities for keeping in line with the on-going developments across the globe and prepare itself in order to be compete successfully in the near future.

Considering the above view, we are motivated to take the endeavour to conduct an initial research on the topic and hence we intend to make a contribution by ultimately increasing the awareness on the subject.

Following sections in this chapter will present the purpose, scope, structure, expectation and the hypothesis of the thesis.

1.1 PURPOSE, SCOPE AND STRUCTURE OF THE THESIS

The purpose of this thesis is to study the concept of ICT and energy efficiency interaction by developing an innovative approach towards a lower energy intensive economy. Since ICT and energy efficiency are among the hot topics globally discussed in the aim of achieving sustainability, investing in research on these issues should be a high priority for the concerned community. Thus, we are driven by this motive to conduct our study.

The concept of ICT for Energy Efficiency is rather a new field in energy efficiency struggle and it requires significant investment in order to be studied realistically. Regarding the above statement, it is important to contribute to the developing field of ICT for Energy Efficiency by conducting studies and research at any level that could support developing a solid structure to this research area that is ultimately needed in this initial stage.

As in the case of our study, growing economy of Turkey will inevitably reveal similar problems and should immediately initiate a capacity building endeavour in order to tackle these issues. Besides, European Union takes the issue seriously and has initiated many attempts in the aim of developing the legislative framework on ICT use for energy efficiency. Considering Turkey's process of integration to the union it will be a necessary strategic path that Turkey should keep in line with the on-going developments.

In this motivation, our study aims at organizing a common analysis structure for ICT for Energy Efficiency by a literature review, defining significant concepts, addressing certain characteristics and illustrating several applications for ensuring energy efficiency. Moreover this thesis aims at bringing together different approaches and discussions to formulate a common basis to investigate further on the subject. Accomplished structure is an elementary tool for mapping fundamental ideas and will be a guide to examine a given case.

Since, most of the discussed issues on the literature have applications and examples in Turkish Consumer Electronics sector, which has significant impact and share on the market, one of the main purposes of our study is to increase awareness among the sector by presenting them the current global trends and on-going developments in this field. We believe it is crucial to disseminate information effectively and; hence, we intend to put first building blocks in the aim of preparing the sector for the upcoming structural changes.

Scope of this thesis is bound to enabling role of ICTs in energy efficiency with examining and also considering its carbon footprints and rebound effects in Turkish Consumer Electronics Sector. Thesis is structured as a case study with literature review and analysis of results followed by policy recommendations. As stated earlier, literature review constructed a common structure for ICT for Energy Efficiency topic and this structure formulated a basis for a qualitative analysis of Turkish Consumer Electronics sector with a semi-structured interview application and a structured SWOT study designed as a simple discussion on the topic rather than a conventional SWOT meeting. Moreover, analysis of the results will depict the current situation of the sector on the issue and will provide inputs for designing policy recommendations.

Originality of the study lies within the fact that there is no academic research or sector studies conducted for the case of Turkey so far and we believe that this study is among the first academic attempts in the search for achieving energy efficiency through utilization of ICTs.

The structure of the thesis consists of five chapters: introduction; literature review that includes sections about enabling role of ICT by application of technical enhancements and through dematerialization, carbon footprint of ICT and rebound effects; method of the field survey; analysis and results of the field survey; and conclusion chapter that sums up the overall discussions along with policy recommendations and suggestions for further research.

This thesis will address the main characteristics of the concept of ICT for Energy Efficiency in order to illustrate and to formulate a structure for the enabling role of ICT. Chapter two begins with a very brief presentation of various approaches and discussions from both European Union perspective and several reports published by organizations and institutions in order to reveal the general framework for ICT for Energy Efficiency concept. First section of Chapter two descriptively presents the definition and meaning of general ICT sector. Following section illustrates and discusses the certain aspects in application of technological enhancements of ICTs in the aim of achieving energy efficiency gains to several areas such as buildings, industrial equipment and automation, and energy grids and power distribution. Third section, presents the second aspect of enabling role of ICT through dematerialization. Section includes discussions and illustrations of dematerialization in the society and in the management and process support. Even though not all the techniques and methodologies discussed through the enabling role of ICT presents practical use and remain more theoretical, most of them guides us toward structuring a framework that we could investigate in our case study.

Chapter two continues with the discussion of carbon footprint of ICT and the concept of rebound effect. These concepts are briefly presented in this literature review to give us an understanding and importance of the on-going debates since there are no commonly agreed discussions, particularly on the rebound effects, due to their complex nature including a broad range of factors affecting their validity domains. However, these concepts are important to assess the enabling role of ICT in energy efficiency and they are required to be acknowledged by the actors from the sector considering our scope.

Chapter three elaborates on the details of the purpose of field study, also including the method for data collection. In this chapter, we investigate the inclusion of ICT to the selected sector and; thus, practice to depict the current situation of the firms within the sector regarding their products, strategies and work routines. The sample group was chosen as the top three biggest firms in the Turkish Consumer Electronics Sector, Bosch Siemens Home Appliances Group (BSH), Arçelik A.Ş. and Vestel A.Ş. respectively.

Chapter four presents the results of the conducted field survey indicating the level of inclusion of ICT to the sector for energy efficiency gains and revealing the awareness of the sector. Testing the validity of our hypothesis also included in this chapter.

Chapter five includes the policy recommendations on enabling the potential of ICT to be used in energy efficiency achievements in Turkish Consumer Electronics sector by addressing the needs, defining the goals and proposing policy instruments. Regarding the importance of the developments in ICT and the global trends in search for new ways of elaborating proposals in energy efficiency issues, this thesis will contribute to initiate actions in Turkish Electronics Sector for bringing the sector in line with the global context by policy recommendations. Chapter also concludes the thesis and contains a section for further research suggestions.

1.2 EXPECTATIONS AND HYPOTHESIS

In this study, expected outcome of the literature review is to familiarize with the concept of ICT for Energy Efficiency and; thus, formulate a common structure to analyse the issue for the case of Turkish Consumer Electronics Sector. Another expectation is to present the structured view and current developments on the topic to the selected sector by ensuring an awareness increase as well as to obtain information on the awareness level of the sector. It is intended here to reveal the current structure of the leading firms in the selected sector on the ICT for Energy Efficiency topic and to assess their strategies towards investing in these technologies within their business model.

The hypothesis of the thesis can be defined as;

Utilization of ICTs can help improving energy efficiency in consumer electronics sector in Turkey.

Although there is a debate on the impacts of ICTs on environmental instances and energy efficiency, according to literature a realistic and effective utilization of ICTs can result in significant achievements in energy efficiency. Problems generally arise from the fact that currently there are no standards or concrete methodologies developed for this specific case according to studies and research conducted on the potential of ICT utilization (Webb, 2008).

However, as we observe from the literature, along with traditionally practiced methodologies benefiting the capacity of ICT in a limited way, there are serious endeavours and achievements in tackling the energy efficiency and environmental problems.

To achieve success, the prominent factor is the increasing level of awareness and; hence, shifts in people's behaviour altering conventional practices with developing new ways of working through sustaining social and economic activities. Required potential for the success lies within the abilities and concern for capacity building. The intention of keeping in line with the global context further supports the endeavours.

Throughout our literature survey, we observed that serious steps have begun to be taken and noticeable achievements have been made. Thus, we wanted to investigate whether Turkey had followed these achievements and developments.
If we find out that there is a potential for ICT-empowered energy efficiency practices in the scope of our study, we will contribute in realizing this inclusion by designing policy recommendations mainly aiming at initiating actions towards bringing the sector under investigation in line with the global structure on ICT for Energy Efficiency issue.

We will test the hypothesis using the general framework and results from our field survey by assessing the current structure and general characteristics of the surveyed firms regarding the theoretical background of ICT for Energy Efficiency concept. Furthermore, we intend to formulate ideas and; thus, design policy recommendations according to these findings.

CHAPTER 2

ICT FOR ENERGY EFFICIENCY

There are various approaches incorporating energy efficiency through utilization of ICT. Many of them converge to similar terms and concepts and addresses common issues. In this chapter, we will analyze mainly the Eurocentric view since our case study is directly related and bound to technological and political approaches developed by European Community considering the case of Turkey. Basic definitions of concepts will be followed by review of two main paths towards energy efficiency: by technological application of ICT and through dematerialization strategies as the result of technological innovations in ICT. A discussion of carbon footprint of ICT sector and the concept of Rebound Effect will provide a concrete base for the analysis of the issue with the controversial views. Here, European Commission's view and discussion of several reports published on the issue will construct an overall picture for setting the scene for our study.

Having been stated the Eurocentric view of the study; European Commission (EC) claims that transforming Europe into a low-carbon, high energy-efficiency economy requires minimization of energy consumption while keeping the continued growth of the European economy. However, if no measures were to be taken, EU predicted that final energy consumption would increase up to 25% by 2012 with a drastic rise in greenhouse gas emissions (EC, 2008).

To tackle this issue, EU claims that, Information and Communication Technologies (ICT) have an important role in reducing energy intensity and increasing the energy efficiency of the economy. Thus, it is commonly agreed that ICT can enable reductions in emissions and contributes to sustainable growth. Furthermore, commission expects that ICT will not only improve energy efficiency and challenge climate change; they will also stimulate the development of a large leading market for ICT-enabled energy-efficiency technologies. This result is expected to create new business opportunities as well (EC, 2008).

EU also states several needs to be achieved in order to put ICT at a focal point in the energy efficiency effort. First, in order to reduce energy intensity of the economy by implementing intelligence to components, equipment and services, a serious research effort should be taken on ICT-based solutions. Second, since ICT industry accounts for about 2% of global CO2 emissions through all kinds of economic and social activities (Gartner, 2007), ICT should reduce its energy requirements. Third, structural changes should be realized in order to reveal the potential of ICT to enable energy efficiency for instance by substituting physical products by on-line services, moving business to internet and adopting new ways of working like videoconferencing (EC, 2008).

According to EU political framework, EC focuses on two main areas; first, ICT itself since it is a visible consumer of energy; second, ICT as an enabler to improve energy efficiency through enabling new business models, improved monitoring and finer control of all sorts of processes and activities; since, now all sectors of economy are increasingly ICT depended (Herring, 2007).

Besides European Union’s efforts in structuring the energy efficiency issue by utilization of ICT, there are also several supporting studies and reports developed and published by various authors or institutions. In the following, we discuss and present some of the most relevant one in assessment of developing a structure for our analysis.

Pathways to a Low-Carbon Economy report by McKinsey provides a global greenhouse gas abatement cost curve, which estimates the potential and costs of more than 200 GHG (Green House Gas) mitigation activities across 10 sectors and 21 world regions. According to this report, there is a potential to reduce the GHG emissions by 35 percent by 2030 compared with 1990 levels. The activities are divided into four categories: energy efficiency, low-carbon energy supply, terrestrial carbon (forestry and agriculture), and behavioral change. Regarding the three first categories, the report estimates that 33 percent of the abatement potential lies in land-use sectors (agriculture, forestry), 29 percent in energy supply sectors (electricity, petroleum and gas), 22 percent in sectors with significant consumer influence (transportation, buildings, waste), and 16 percent in the industrial sector. Regarding the last category, the report claims that changing behavior is difficult and will greatly depend on the kind of incentives policy makers are able to offer (McKinsey&Company, 2009).

The report *SMART 2020* the Global eSustainability Initiative (GeSI) evaluated the impacts of direct emissions of ICT products and services based on expected growth in the ICT sector. It also assessed areas where ICT could enable significant emission reductions. The report states that ICT's largest influence will involve enabling energy efficiency in other sectors and not in increasing the energy efficiency of ICT products and services. The biggest role ICTs could play is in helping to improve energy efficiency in electricity supply infrastructure, the power consumption of buildings and factories and the use of transportation to deliver goods. Consequently, by realizing the opportunities in smart motor systems, smart logistics, smart buildings, and smart grids, ICT could produce emissions savings of approximately five times larger than the total emissions from the entire ICT sector in 2020, translating into savings of approximately €600 billion. The report also stresses that in order to enable the potential of ICT for sustainability: major policy, market and behavioral changes are required (Webb, 2008).

Gartner's report *Green IT – The New Industry Shock Wave* concentrates on the potential changes that greener ICT could have on business practices. The report also draws attention to the issue of "green fatigue" on the agenda, i.e. the over-exposition of green information and the attitude people could adopt towards this information. The report also presumes that green IT will go through the same cycle as every new developing technology. Report claims that only after a big one it is possible to evaluate the actual roles of green IT in society. Gartner notes that the motivation of midsize enterprises in moving towards green IT is mainly cost savings. Importantly, the report notes that the big opportunity for the IT industry lies in the use of ICT to reduce the overall environmental impact of enterprises instead of focusing on the footprint of the ICT hardware (Mingay, 2007).

Another Gartner's report, *Green IT – Where to Invest* aims at defining those "green industry" segments that investors should consider seriously while green values are promoted in almost all products. Gartner has worked with its clients to define the most important topics of green IT (Mingay, 2008a).

The key finding of the third Gartner report *IT's Role in a Low-Carbon Economy* is that the ICT industry is the winner in the future low-carbon economy as new business opportunities are opening in many fields. The current contribution of ICTs to low-carbon economy is considered modest, with the exception of teleconferencing solutions. The report lists some of the fields where ICT can make significant environmental impact: (Mingay, 2008b)

- Fuel-efficient vehicles
- Energy-efficient buildings
- Forest management
- Transportation management
- Travel substitution
- Carbon accounting and eco-labeling
- Flexible working
- Process analysis and optimization
- Supply chain management
- e-business and e-government
- Environmental management systems

Furthermore*, The Potential Global CO2 Reductions from ICT Use* report is the result of collaboration between WWF (the World Wildlife Fund) and HP (Hewlett-Packard). The purpose of the report is to identify ICTs that could contribute to vast amounts of reductions in CO2 emissions. The following solution areas were identified: 1) smart city planning, 2) smart buildings, 3) smart appliances, 4) dematerialization services, 5) smart industry, 6) i-optimisation, 7) smart grid, 8) integrated renewable solutions, 9) smart work, and 10) intelligent transport. The report is written from a positive perspective instead of merely listing the problems. It concentrates on new business opportunities initiated by climate change. The potentials of various green ICT solutions for emission reduction are presented and compared in the report (WWF, 2008).

In the *Saving the Climate at the Speed of Light* report, the European Telecommunications Network Operators' Association (ETNO) and WWF present a roadmap for reducing CO2 emissions in the EU and beyond. The report states that in order to achieve the necessary reductions of CO2 dramatic structural changes in infrastructure, lifestyles and business practice are required. The effects of ICT are divided into three groups: direct, indirect and systemic. The gap between the academic studies discussing theoretical potentials of technologies and policy makers requiring specific information of what needs to be done is noted and the roadmap report attempts to minimize this gap. Report assesses that the focal point in environmentally sustainable ICT is mainly on products instead of services and ICT sector do not consider green ICT as a business opportunity. The report presents three real-world case studies of ICT for environmental sustainability in the areas of travel substitution, sustainable consumption and new combined services. Reducing the need for travel is identified as the most obvious short-term way for ICT to reduce CO2 emissions. The report also emphasizes the need for decision-making at the high-level governmental level and for policies related to sustainable development. (Pamlin and Szomolányi, 2006).

To sum up the analysis of the reports, there are some general conclusions that can be drawn from the reports presented briefly above. For instance, most of the reports focuses on the potential of ICTs in other sectors instead of the ICT sector itself. In other words, the environmental impacts of applying ICT in other economic sectors are estimated to be greater than those of intensifying and gearing up the ICT sector itself. The reports also point out that ICT is both part of the problem and part of the solutions. Since developments in ICT also enabled more resource consuming lifestyles and primarily increased the resource intensity of ICT itself. Thus, the environmental footprint of the ICT sector is an important issue that should not be neglected.

Another view shared by the reports is making a significant impact and changing the process require the society undertake major systemic changes in both structure and behavior. The reports seem to approach environmentally sustainable ICT from the viewpoint of industry but do not consider how people, citizens and consumers, can contribute to the low-carbon economy. However, new incentives and policies that steer both the companies and citizens, consumers towards more sustainable behavior are needed. Consequently, policy-makers and governments have a leading role in tackling this issue.

Finally, most of the reports and the corresponding research is now concentrated on just climate change, the mitigation of GHG-emissions and adaptation. Although this is an important issue, sustainability and efficiency are topics that have broader domains than climate change.

Regarding the above view we have identified the following topics to investigate further. First, enabling role of ICT in energy efficiency will be reviewed in two axes; by application of technological enhancements of ICT and through dematerialization. Second, concept of carbon footprint of ICT and the rebound effects will be presented briefly to support the discussion as a whole. Before going into details we will also provide definition of ICT in general to begin with.

2.1 WHAT IS ICT?

Definition of ICT in a generic manner will provide a better understanding for its domain, capacity and potential for innovative approaches to several issues being discussed in this study.

In general, Information and Communication Technologies (ICT) is a term that includes all forms of technologies that process information and help communicating in digital format, i.e., creation, acquisition, processing, storage, retrieval, transmission, exchange, and dissemination. In order to activate those processes, ICT consists of hardware and software components including computers, mobile phones, printers, wireless networks, applications and services such as decision support systems (DSS), service oriented architecture (SOA), enterprise resource planning (ERP), videoconferencing, e-commerce, e-learning, and so on.

It is commonly agreed that ICT consist of diverse areas as business, industry, environment, government, communication, health care, scientific research, education, etc. Moreover, it is common that ICT is synonymous with IT as ICT is an umbrella term for information technology (IT) and communication technology.

At this point when we refer to Herring, he presents a direct definition for Energy efficiency as the ratio of energy services out to energy input. In other words getting the most out of every unit of energy produced or consumed. He argues that it is a by-product of better expectations from a given service or product such as productivity, comfort, monetary savings or fuel competition (Herring, 2007)

The challenge here is to merge these definitions to prevail a newer way of thinking that would enable improvements in energy efficiency with the utilization of ICT. Following sections will present us this enabling role of ICT in a descriptive manner so that to illustrate this phenomenon clearly.

2.3 ENABLING ROLE OF ICTS IN ENERGY EFFICIENCY BY APPLICATION OF TECHNOLOGICAL ENHANCEMENTS

This section will present a review of the approaches and practices of ICT applications in ensuring energy efficiency through technological enhancements in three major areas: Low-Energy Buildings, Industrial Equipment and Automation, Energy Grids and Power Distribution. We will use these theoretical and practical illustrations in designing our field survey to assess our goals in depicting the inclusion of ICT in the Turkish Consumer Electronics Sector. More specific and technical discussion of the following section can be found in Appendix A.

2.3.1 Low-Energy Buildings

It is commonly agreed that the energy consumption of buildings is mainly related to heating systems, ventilation and cooling, lightning, large electrical and electronic equipment including elevators, escalators and white goods and ICT is the crucial element to an effective system such as a low energy building (Lenormand, 2005). The vast monitoring and networking capability, which ICT provides, can support the architectural and environmental conditions of buildings with its main installations such as HVAC, lighting, security systems, and large electrical equipment (BIS, 2008).

ICT contributes here as a networked sensors, control, and actuator system making the building infrastructure "smart" by functionalities such as; monitoring of conditions (sensors), transmission of sensor data (networking), processing, storage and display of data (software-based control), actuating in response to the controllers command (actuator).

There are many ways that ICTs can help in improving energy efficiency of buildings. Firstly, ICTs provide connectivity. That means, ICTs link elements in the building infrastructure and enables an automatic reaction to changing conditions allowing energy utilization within a given building infrastructure. Secondly, ICTs provide flexibility. ICTs enable an effective allocation or modification of equipment in the existing building infrastructure, allowing installing energy saving equipment in shorter times without a complete system replacement. Thirdly, ICTs supply information. ICTs provide useful information by sensor data to the system administrator or user. This information helps to analyze energy saving potentials and could result in adjustment of the operation parameter. The sensor data are also used for detecting operations or maintenance demand. Thus, energy saving is in this case related to more optimized servicing and the prevention of system breakdowns. Fourthly, ICTs supply ambient intelligence. ICTs provide a technology that will become incorporated in our natural surroundings and present whenever we need it. That technology will be enabled by simple interactions and will be adaptive to users (Weber, 2005). Lastly, there is ICTs capability of miniaturization. The performance of ICT is related to miniaturization in the field of semiconductor technologies. ICTs develop into micro- systems where the small size allows the easy implementation of ICTs into any equipment. It also allows utilization of new types of energy for running the ICT system such as ambient energy sources (e.g. vibration, changes in temperature or electromagnetic field) (Ibid).

We will discuss the application of ICTs in buildings in three main areas; first Heating, Ventilation and Air conditioning (HVAC); second, Lighting and Security Systems and third, Other Electrical and Electronic Equipment in Buildings.

2.3.2 Industrial Equipment and Automation

Industrial equipment includes all kinds of machines including large electrical tools, robots, cranes, engines, fans, pumps, galvanic baths, incinerators, furnace equipment, ovens, shakers, and coverer belt systems. Such industrial equipment is commonly applied in energy-intensive manufacturing for raw material refinery, preliminary product manufacturing, and of course for the production of final goods (BIS, 2008).

Although, factory and process automation sector has been already utilizing electromechanical and electronic measurement and control solutions, ICT applications could support the growing demand of controlling manufacturing equipment and processes in real time, as well as handling products and logistics information fast and safely.

To illustrate, sensors for measuring thermal, mechanical, electrical, optical, acoustical, and chemical conditions are key applications of ICT. The digitalization of sensors based on advanced semiconductor is the main driver to increase functionality such as higher speed and accuracy.

According to many studies, with the technological progress in ICT, the factory and process automation technology can take a great step forward towards: real-time control, event prediction, process visualization, micro-sensors with integrated digital data processing, energy autarkic sensors based on energy harvesting technology and build-in or mobile wireless sensor networks.

One ICT based application, which illustrates the role of ICT in factory and process automation, is the use of Wireless sensor networks. Wireless sensor networks (WSN) allow a precise control of machinery, equipment, manufacturing lines and processes. WSN consist of autarkic sensor nodes configured in a wireless network. This technology is still in development, but has huge potential in the field of automation (BIS, 2008).

2.3.3 Energy Grids and Power Distribution

ICT can also offer renewable energy based opportunities in smart grids for energy efficiency. Decentralized energy production could allow renewable energy sources to be integrated into the grid, reducing coal based generation and therefore emissions (Webb, 2008). The cost effectiveness remains the main challenge regarding the creation of a new management system, which integrated the renewable sources in the distribution grids networks (EEF 2008).

However, it is important to promote the deployment of intelligent systems that integrate power generation from renewable and consumption using the high level ICT solutions. According to that, a very good prediction of the wind has to be feed into the system to manage the energy supply (EEF 2008). In addition, in the context of technological development, the way forward is to involve researchers from different domains (ICT, energy, renewable energy, sustainability).

It is also important to bring together and create communication channels between producers (solar and fuel cells, wind mills, biomass, etc.), consumers, energy service providers, and network operators. Implementing ICT infrastructure for communication with producers and consumers allows for the automated control of producers and consumers (EEF 2008). It is also beneficial to incentivize efforts associated with joint projects supporting the integration of power generation and distribution grids with renewable energy sources.

2.4 ENABLING ROLE OF ICTS IN ENERGY EFFICIENCY THROUGH DEMATERIALIZATION

Dematerialization can be defined as “the reduction of the total material and energy throughput of any product or service, and thus the limitation of its environmental impact. This includes reduction of raw materials at the production stage, of energy and material inputs at the use stage, and of wastes at the disposal stage (UNEP, 2001).

In other words, dematerialization, in general, is the reduction of material and resource use for achieving an either equal amount or increased quantity and quality of production of goods or services at all levels in the economy.

Relatively dematerialization refers to the phenomenon of de-linking economic growth and natural resource use, i.e., meaning that progressively, less materials and energy are used per unit of economic value produced. Thus, economic growth is separated from the natural resource base (BIS, 2008).

This definition is also in accordance with the term of eco-efficiency defined by World Business Council for Sustainable Development as "the delivery of competitively priced goods and services that satisfy the human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity [...]" (WBCSD, 2007) or more simply as "doing more with less". This can be achieved through the use of ICT-based services and technologies.

Dematerialization through the use of ICT can further be explained as;

- The replacement of material goods by non-material substitutes - "Bits instead of atoms" (for instance a letter on paper replaced by an electronic mail)
- The reduction in the use of material systems or of systems requiring large infrastructures (for instance using telecommunications instead of using a car to go to work)
- The conception and manufacture of products using less materials and energy and conception of a smaller or lighter product (BIS, 2008).

This section will be followed by illustrative descriptions of applications and services incorporated by dematerialization concept in two main axes; dematerialization of society and dematerialization in management and process support.

2.4.1 Dematerialization of Society

This sub-section will focus on three specific areas of dematerialization:

- Teleconferencing: Audio/video conferencing and e-work
- Dematerialization of materials and services
- e-Banking and e-Commerce

2.4.1.1 Teleconferencing: Audio/Video Conferencing

According to European Environment Agency findings, passenger transport volumes have increased with economic development, and ICT could provide help in dealing with transport growth and economic growth by offering alternatives to physical passenger transport. Audio conferencing and video conferencing are two ICT-based practices allowing travel replacement.

A recent report analysis done by Webb (2008) also found that although other dematerialization opportunities may come to prominence in the future, based on historic trends, teleconferencing and e-work would have the largest impact on energy savings and lower emissions (Webb, 2008)

Moreover, according to IEA (2004), transportation is a large and growing emitter of GHG, responsible for 14% of global emissions. With this technology, people can work and conduct meetings from home using broadband access and wireless communications instead of using offices; thus, they will be positively impacting the environment. Some scientists argue that due to the fact that e-work minimizes the need for transport and therefore environmental pollution and energy intensity of the sector would be reduced (Fuchs, 2008)

European Commission also defines e-work as any normal business activity carried out from a remote location by using modern computing and communication technology including activities such as audio-conferencing and video-conferencing and enable reduced business travel.

Another aspect of reduced commuting enabled by e-work is enabled through the use of ICT equipment and technologies such as: collaboration software and tools such as instant messaging services, conferencing services, software for sharing documents and comments with clients, colleagues or business partners, etc. (BIS, 2008),

To illustrate the potential of this technology regarding efficiency and lower emissions, according to Webb (2008), if 10% of the EU workforce become flexi–workers, this could save 22.17 million tons of CO2 a year. The same argument is valid for teleconferencing that by substituting personal meetings by teleconferences travelling can be reduced. If 20% of business travel in the EU were replaced by video conferencing, this would save 22.3 million tons of CO2 (Webb, 2008)

2.4.1.2 Dematerialization of Materials and Services

In this sub-section utilization of ICT enabling replacement of physical products or services by digital products or online services are covered and some of the main applications of dematerialization concepts are briefly presented.

A lot of these e-goods are enabled by the potentiality of ICT to reduce the amount of paper-based documents and transportation needs. Conclusions on the possible environmental benefits of such digital goods and services indicate that purely digital distribution of e-goods is clearly beneficial from a material intensity point of view, compared to the physical products. However this conception is valid only under the assumption that the user does not rematerialize the digital goods such as burning music on a CD (BIS, 2008). Such instances remark the noticeable impacts on efficiency issues by behavioral instances.

2.4.1.3 e-Banking and e-Commerce

The services provided by online banking (e-banking) emerged from allowing customers to consult their accounts to providing a full range of banking services. In the most developed applications, the Internet can replace almost the whole range of services available at branches or by phone. In addition, by offering nearly all branch based services, the technology allows banks to offer new added value services such as e-mail alerts, electronic commerce, real-time share trading and 3rd party services such as the management of utility bills and tax payments. The most frequently used services are those that provide financial information (account information, loan and insurance rates, investment reports and advice). Other heavily used services are simple transactions such as paying bills and transferring money (BIS, 2008).

Electronic invoicing (e-invoicing) is the utilization of invoices by email directly to the customer. The European commission defines e-invoices as: “the electronic transfer of invoicing (billing and payment) information between business partners.” The European e-business w@tch 2005 special report provides the following definition of e-invoices: “Electronic invoicing is a computer-mediated transaction between a seller/biller (invoicing entity) and a buyer/payer (receiving entity), which replaces traditional paper-based invoicing processes.

In e-invoicing, the invoice is electronically generated and sent by the biller and electronically received, processed and archived by the payer. E-invoicing can either be accomplished in a web-based environment or processes can be integrated with the ERP system of a company (BIS, 2008)

E-commerce is a part of e-business. E-business can be defined as follows: “business processes, commercial activities, or other economic tasks conducted over the Internet or computer mediated networks such as internet and etc.…”(Fichter, 2002). The OECD501 provides the following definition: “Electronic commerce refers to commercial transactions occurring over open networks, such as the Internet. Both business-to-business and business-to- consumer transactions are included.

E-commerce can be applied to different sectors through: e-retailing (online sale of tangible goods); online gambling (casino and card games, sports and other betting, lotteries); pharmacy/e-health (online sale of drugs, medicines, and other healthcare products); telecommunication services (from mobile phone contracts and pre-paid phone cards to website hosting services); and travel (travel services, packaged holidays, car rentals, etc.) which appear to be at the forefront of e-commerce (Pago, 2007)

Information technologies and e-commerce are transforming manufacturing (e.g. digitalization of products) and distribution processes. In doing so, it has the potential to reduce or eliminate the need for products, for warehouses and retail stores, and energy, space and material they consume. Moreover, at first glance, it could have beneficial effects on transport (BIS, 2008)

2.4.2 Management and Process Support

This sub-section has the objective to analyze the energy efficiency potential of ICT applications in the field of management and process support. The focus is placed on the assessments of latest technologies and applications for ICT-enhancement in two main areas: Identification, tracking and tracing with radio frequency identification (RFID) and Computer-aided design, simulation and virtual reality.

2.4.2.1 Identification, Tracking and Tracing with Radio Frequency Identification (RFID)

According to the “European Policy Outlook RFID” paper, referenced at the European conference "RFID: Towards the Internet of Things" on the 25th and 26th of June 2007 in Berlin, RFID is providing the linkage between the “world of production” (represented by the material good) and the “world of service” (represented by digitalized information). With RFID tags, objects become “smart” and can be networked together and communicate with their environment. According to paper, RFID technology will optimize existing processes in various industrial sectors and it is also expected to create opportunities for new business models that will take advantage of a global network in which any object can be linked to any context (RFID, 2007)

Many sectors can benefit from RFID as a technology to optimize existing processes, improve reliability, offer new services and realize the advantages of rationalization. With the growing availability of highly miniaturized passive and active transponders (RFIDs) including respective electronic scanner gates or sensors it is now possible to identify and localize goods within the supply chain very fast and even without visual contact. The main applications are therefore the identification, tracking and tracing of materials and goods in manufacturing, logistics and retail sales is increasingly based on RFID technology. (BIS, 2008)

RFIDs; however, can also be used for faster locating objects, positioning and navigating machines. One example is the Local Positioning Radar developed by Symeo. Symeo develops and applies contact-free sensor technologies to provide highly reliable distance measurement, positioning and navigation in real time. The Local Positioning Radar (LPR) uses radio signals, which are not susceptible to though environmental conditions. Symeo only use radio frequencies in the internationally freely available ISM-bands (Industrial, Scientific and Medical). Symeo equipment can be deployed indoor and outdoor under vibrations, extreme temperatures, dust and harsh weather conditions absolute positioning.

In conclusion, RFID applications show a good potential to improve the time and cost efficiency, the quality of services and security of processes. It seems justified to assume that the shorter process times have a positive effect on the energy consumption, if we take the example of conventional stock taking, sorting and checkout of goods in a warehouse with a laser beam barcode scanner or with an antenna scanner gate for RFID labeled goods on a pallet (BIS, 2008).

2.4.2.2 Computer-Aided Design, Simulation and Virtual Reality

As debated in Evans study, the IT industry promotes a “four pillars" model, which builds the basic information technology support structure in business or corporate environments (Evans, 2004). These four cornerstones are:

Product Lifecycle Management (PLM): to create and document the products being designed and the processes to manufacture them. PLM is the process of managing the entire lifecycle of a product from its conception, through design and manufacture, to service and disposal.

Customer Relationship Management (CRM): to identify customers and prospects for the enterprise, to provide a complete picture of contacts with them and enhance communications effectiveness.

Supply Chain Management (SCM): to optimize the capital tied up in inventory and their unit costs. SCM encompasses inward and outward logistics systems that acquire materials to make products and ship finished goods to customers.

Enterprise Resources Planning (ERP): to provide a single financial view, for as many departments as possible, of internal and external transactions that either add value or transform the status or location of a product, part or asset.

Of these four main pillars of corporate IT the Product Lifecycle Management (PLM) provides the specific IT tools that can support an energy conscious product and process designs. The following main PLM tools have to do with managing properties of a product through its development and use life from a business and engineering points of view (Ibid).

Eco-design experts frequently argue that “approximately 80% of all product-related environmental impacts are determined during the product design phase”

(EcoDesignARC, 2006). Considering environmental aspects in the design phase is therefore the most effective approach to improve energy efficiency of products, infrastructure, manufacturing processes, etc. The IT support tools for digital product development are typically in three tool categories and two application categories on the market (BIS, 2008):

Computer-aided design (CAD) is the use of computer technology to aid in the design, development and optimization of any kind of products, equipment, process or structures such as buildings. CAD is mainly used for detailed engineering of physical components through 2D vector base drafting systems to 3D solid and surface modelers. CAD enables designers to layout and to develop their work on screen, print it out and save it for future editing.

Computer-aided manufacturing (CAM) is the use of computer-based software tools that assist engineers and machinists in manufacturing or prototyping product components. CAM is a programming tool that allows you to manufacture physical models using computer-aided design (CAD) programs. CAM creates real life versions of components designed within a software package.

Computer-aided engineering (CAE) is the use of information technology for supporting engineers in tasks such as analysis, simulation, design, manufacture, planning, diagnosis and repair. Software tools that have been developed for providing support to these activities are considered CAE tools. CAE tools are being used, for example, to analyze the robustness and performance of components and assemblies. It encompasses simulation, validation and optimization of products and manufacturing tools.

Computer simulation (CS), computer model or computational model is a computer program, or network of computers, that attempts to simulate an abstract model of a particular system. Computer simulations have become a useful part of mathematical modeling of many natural systems in physics (computational physics), chemistry and biology, human systems in economics, psychology, and social science and in the process of engineering new technology, to gain insight into the operation of those systems, or to observe their behavior.

Virtual reality (VR) is the use of computer modeling and simulation that enables a person to interact with an artificial three-dimensional (3-D) visual or other sensory environment. VR applications immerse the user in a computer-generated environment that simulates reality through the use of interactive devices, which send and receive information and are worn as goggles, headsets, gloves, or body suits (BIS, 2008).

Digital product design and simulation is state-of-the-art and most common in any research, design, and planning process. The development and market of IT-tools for digital product design and simulation is a powerful business with an assumed strong influence on the energy efficiency of products and other infrastructures (BIS, 2008).

Even though computer aided design is used, simulation is probably the only reliable mechanism for predicting and evaluating the performance of the system under dynamic loads and operating conditions without its physical existence. Furthermore, in the future, virtual reality with ambient intelligence will support new designs and the finding of alternatives (Ibid).

Digital product design and simulation tools support industry for creating better products and processes. Generally documented benefits of these tools include: Reduced time to market, improved product quality and performance, reduced prototyping costs, reuse of original data, process visualization, savings through the complete integration of engineering workflows (Ibid).

2.5 CARBON FOOTPRINT OF ICT SECTOR AND REBOUND EFFECT

A definition for carbon footprint can be given as "The carbon footprint is a measure of the exclusive total amount of carbon dioxide emissions that is directly and indirectly caused by an activity or is accumulated over the life stages of a product." (Wiedmann and Minx, 2008).

The ICT sector is viewed as unsustainable and it continues to overlook environmental externalities; however, sector's potential to increase productivity and creation of new ideas reveals its capacity in reaching the goals of a more sustainable development (Romm, 2000). Regarding the fact that the sector itself is responsible for 2% of global carbon emission of year 2007 (Gartner, 2007) and it is estimated to have 6% share in total carbon footprints by year 2020 (Webb, 2008), ICT sector should take measures in enabling its capacity and take a leading role in mitigation of energy intensity and carbon emissions.

The increasing trend of carbon footprint of ICT sector is resulting from performance improvements and innovations of electronics causing exponential growth followed by cost reductions and increasing number of users with higher expectations along with manufacturing impacts (Plepys, 2002). When we examine affecting factors, according to a study user phase has the largest environmental impacts (IPU/AC, 1998). This finding also supported by GeSI estimates such that the carbon generated from materials and manufacture is about one quarter of the overall ICT footprint and the rest is coming from its use (Webb, 2008)

The view presents itself, as ICT sector also need to use its potential to take action towards low emissions and efficiency in energy consumption. Specifically, estimates towards intensive adverse effects resulting from use of ICT relates to our study. Detailed analysis of carbon footprint of ICT sector is not directly within scope of our thesis: however, exponential usage of ICT and its outcomes will be taken into consideration.

This section will briefly present trends in reducing the carbon footprint of ICTs followed by a discussion on rebound effects.

2.5.1 Reducing the Carbon Footprint of ICT

According to Greening (2000), effects of ICT are difficult to analyse since there is no comprehensive theory and empiric data available. Therefore it is difficult to make estimates and predictions towards studying these impacts. However, the small but visible effects of ICT and ICT itself should be studied to develop methodologies for taking preventive measures.

European Union took the endeavor to tackle this issue and puts efforts to make a systematization. In this manner very briefly EU states that the ICT industry is in a position such that it can lead in reducing its footprints through structural change and innovations as well as by revealing ways in identifying and promoting solutions for other sectors to follow. EU focuses on the issue in two stakes.

First, EU aims at making the ICT sector a leading contribution to structural change. Here, structural change is defined as re-engineering the way an organization operates. Furthermore, replacing products with online services, moving business to Internet, adopting new ways of working, exploring the viability of using green suppliers and energy from renewable resources are listed as examples for realizing the structural change.

Second, EU aims at making the ICTs a leading contribution to innovation. According to their view since ICT components, subsystems and end-systems require reduction in energy intensity, emerging technologies such as quantum- or photonics-based computing promising great opportunities should be promoted.

Regarding the fact that studies and research on this specific topic is newly developing; there is no realistic and solid proposal for the issue yet. However, EU puts great effort to come up with solutions and methodologies.

2.5.2 Rebound Effect

As illustrated before, it is clear that ICT can be an enabler for energy efficient, low carbon economy. However, there are a few obstacles that must be taken into account if we want to utilize the full outcome of ICT enabling effect. This issue is related mainly to the rebound effects that should be taken into consideration seriously. In a general manner rebound effect can be defined as the effect on consumer behavior due to lower costs of energy with increased energy efficiency (Frondel, 2004; Herring, 2004). In other words, the rebound effect is the energy savings resulting from efficiency outcomes, which are taken back by consumers with higher consumption tendencies (Herring, 2007). For example, realized lower costs of energy efficient lighting by consumers may tempt them to use the lightning for longer durations for many reasons such as comfort, security or safety.

As taking into account rebound effects, MacLean and Arnaud discuss about some systemic effects that how ICT-enabled changes affect behavioral choices, economic and social structures, and governance processes that determine the patterns of energy consumption. According to them, systemic effects should be holistically studied in order to avoid rebound effects that may threaten environmental gains (MacLean and Arnaud, 2008).

In a recent report, Rubin (2007) also describes the issue as an "efficiency paradox" in which technology improvements allow for energy savings that are lost to greater consumption. In other words, improving the efficiency of ICT equipment directly or increased energy efficiency using ICT, paradoxically, may result in greater GHG emissions (MacLean and Arnaud, 2008). Therefore, according to discussions and findings of the studies, assessing the challenge of energy efficiency through the development and application of ICTs will require changes in producer and consumer behaviors and economic and social structures as well as in governance processes.

In order to put the ICT-enabling potential at a focal point in energy efficiency endeavor may require a more holistic analysis of the referred effects of ICT on the environment. The necessitating action is to increase awareness among all involved stakeholders in order for ICT producers to create solutions; for users to understand and consider environmental implications of ICT use; and for policymakers to design relevant policy frameworks that contribute realistically to the transition to an energy efficient low carbon economy.

As put directly in the SMART 2020 report, if we are intent to utilize ICT technology to transform existing energy intensive consumption tendencies and lifestyles, we need policy innovations, incentives for companies and the active participation of consumers (Webb, 2008). However, referring back to MacLean and Arnold (2008), the relationship between increased energy efficiency and a reduced carbon footprint in the ICT is actually rather complex than being directly straightforward. Overall, making a useful contribution to energy efficiency through ICT applications and overcoming rebound effects remains as a complex challenge; however these concepts should be acknowledged by actors and stakeholders in the path towards utilizing ICT for Energy Efficiency.

2.6 CONCLUSION

In our literature review study, we observed that ICT is both part of the solution and part of the problem, regarding the challenge of achieving energy efficiency. We presented both views in order to grasp the idea of overall conception in utilizing ICT for energy efficiency. However, the enabling role of ICT constitutes the major issue of research in our study, considering our purpose and scope. It was structured and reviewed through two main axes. First, we presented the enabling role of ICT by application of technological enhancements to services and products and second, through dematerialization. Table 1 summarizes the main issues discussed through the review of enabling role of ICTs with the referred two axes.

Table 1 Enabling Role of ICT

By Application of Technological Enhancements	Through Dematerialization
Low-Energy Buildings • Heating, Ventilation and Air Conditioning (HVAC) Systems • Smart lighting and security systems • Other electrical and electronic equipment in buildings	Dematerialization of Society • Teleconferencing: A/V conferencing and e-work • Dematerialization of materials and services • e-Banking and e-Commerce
Industrial Equipment and Automation • Large electrical tools, cranes, engines, pumps, etc. • Factory and process automation	Management and Process Support • Identification, Tracking and Tracing with Radio Frequency Identification (RFID) • Computer-Aided Design, Simulation and Virtual Reality.
Energy Grids and Power Distribution • Decentralized energy production • Integration of energy grids and energy production.	

Moreover, we reviewed the carbon footprint of ICT sector and observed from many studies that share of ICT in total carbon footprints and global carbon emissions show increasing trends and expected to have 6% share by year 2020 (Webb, 2008). However, considering the complex nature of factors, it is difficult to develop comprehensive theories and obtain reliable data for the effects of ICT in the challenge of reducing its adverse impact (Greening, 2000). Nevertheless, we observed that initiatives through developing solutions to this challenge are being held by many organizations, institutions and European Commission as well.

Another topic that we investigated was the concept of rebound effect defined by Herring (2007) as the energy savings resulting from efficiency outcomes, which are taken back by consumers with higher consumption tendencies. Many authors argue that this issue should be taken seriously if we want to utilize the full potential of ICT's enabling role in energy efficiency. However, due to the lack of standards and common methodologies in studying the issue, subject still keeps its controversial nature.

Regarding above discussions, we analyzed the enabling role of ICT by application of technological enhancements and through dematerialization as well as carbon footprint of ICT and rebound effect. This structure will be our guide throughout this study and constitutes the basis in designing the field survey. The next chapter presents our methodology and data collection processes.

CHAPTER 3

METHODOLOGY

This chapter presents the purpose of the field study, method, and data collection in detail with procedures of design and application of the semi-structured interviews with the representatives from major producers of Turkish Consumer Electronics sector and a structured swot discussion study.

3.1 PURPOSE OF THE FIELD STUDY

Purpose of the field study is to assess whether Turkish Consumer Electronics incorporate ICT in their energy efficiency strategies and assess the level of awareness of the sector. Another important purpose of the field study is to present the overall concept of ICT for Energy Efficiency to the sector representatives according to our structured literature review outputs and initiate an awareness increase action across the interviewed firms and the selected sector.

In particular, we investigate whether firms in the sector incorporate and provide ICT-empowered products or services within their domain, their arguments on marketing, whether they possess an understanding for rebound effects and their strategies for handling the issue, whether they incorporate dematerialization techniques and activity tracking methodologies for carbon footprint and life cycle assessment, and whether they have strategies for further exploring the referred concept.

Furthermore, by achieving the above assessment, another objective of the study that is addressing the needs and goals for designing policy recommendations towards the development of capacity building in the sector will be completed. Hence, awareness level within the sector will be increased accordingly.

3.2 METHOD AND DATA COLLECTION

As stated before, our aim is to examine the inclusion of ICT in enabling energy efficiency by Turkish Consumer Electronics sector. In addition to that, another prominent factor in our attempt is to acknowledge the level of awareness about the issue in the sector and to disseminate the information that we structured. In order to achieve these goals, data collection was performed consistently with our structured literature review that is specific to our scope. Thus, collected data will further be analysed to test our hypothesis and will formulate a basis for policy recommendations.

Data was collected by face-to-face interviews with individuals and groups consisting of high level managers and engineers who are capable of providing quality information to our study within their domain of responsibilities at related departments within their firms. The interview designed as a semi-structured interview with open-ended questions aiming at exploring the products or services utilizing ICT for Energy Efficiency in the sector and examining the operational processes in production or supply of ICT-empowered products/services enabling energy efficiency. In general, the types and methodologies or approaches of ICT tools and applications utilized in production or in marketed products in the sector towards enabling energy efficiency, market share of these products, problems of the sector in promoting these product or services, and the strategic plans of the firms towards developing new products or services with this ICT approach were examined. The highlighted points in the interview are formulated according to the literature review and are consistent with our structured framework.

Regarding the fact that the topic under our study is relatively a new concept for both globally and also for Turkey, a requirement for briefing the representative groups on the subject of the study and the general context revealed itself. Thus, before the interviews took place, an introductory presentation of the main points and arguments about ICT for Energy Efficiency provided to the interviewed groups before the meeting sessions and also at the meeting sessions. Interview questions and the provided to the representatives of the selected firms can be found in Appendix B.

A preparation phase was conducted before the data collection and field survey. After structuring the literature review and determination of the relevant sector and selected firms for our case study, purpose, aim and scope of the survey was developed consistently with our framework. Successively, methodology for data collection was chosen and interview design with questions covering the literature was completed. The details of the methodology and survey is as follows:

- The sampling group for the field survey has been determined consisting of three major producers of the Turkish Consumer Electronics Sector.
- Sampling group identification was followed by arrangements of the meetings to conduct the face-to-face interviews with the representative groups from the firms. In order to spot the relevant departments and the right people for meetings, a desktop research was completed together with communicating with people in the sector who might have the right contacts for our study.
- After acquiring several contacts information, the preliminary background-briefing document with the requests for arranging meetings was sent to the identified contacts. Feedbacks and replies from the contacts directed us to the most related people to our framework. Consequently, Innovation and Technology Management Regional Technology Department from Bosch and Siemens Home Appliances Group (BSH), Sustainable Development Energy and Environment Department from Arçelik A.Ş. and Research and Development Department from Vestel Elektronik A.Ş. were informed about our survey and meetings were arranged accordingly.
- Meetings for interviews and briefings took place in Istanbul and Manisa where the selected firms are located. From BSH, Mr. Murat Yücel (Manager, Innovation and Technology Management Regional Technology Department) with his team was interviewed at BHS Istanbul Technical University Office in Istanbul, from Arçelik A.Ş; Mr. Fatih Özkadı (Manager, Sustainable

Development Energy and Environment Department) was interviewed at Arçelik A.Ş. Tuzla Premises in Istanbul. We intended to arrange the meeting in Vestel A.Ş. with Mr. Mehmet Ali Acar (Director, R&D Department); however, due to his busy schedule we cannot contact him further. Instead, Mr. Erhan Yılmaz (R&D Engineer) was interviewed at Vestel A.Ş. campus in Manisa.

- Interview questions with a background information was structured in advance and was sent to the representatives to make themselves acquainted with the concepts and the framework of our study. The meetings began with a brief presentation of our study followed by an informative discussion of the topic and ICT for Energy Efficiency concepts in the aim of, first, increasing the awareness of the sector on the topic and, second, focusing the interview to this newly developing concept. After the discussion sessions, semi-structured interviews with open-ended questions were conducted. Each meeting, approximately, took one and a half hour to two hours in duration.

Regarding the subject of study again, ICT for Energy Efficiency concept is a very high level innovation in energy efficiency issues and it is still in its development phase; hence, conducting field surveys and doing interviews come with their own burdens that needed to be overcome. These burdens can be elaborated such that prominently most of the concepts within in the study are newly emerged thus making them relatively difficult to comprehend without any introduction. Moreover, most of the questions in the interview do not have a specific answer regarding the nature of the topic: therefore, they needed to be discussed and explained thoroughly in order to collect quality data. In addition to that; since, one of the prominent goals of this thesis is to increase the awareness of the sector on our topic by dissemination of the knowledge we have structured, face-to-face type of semi-structured interviews applied to the representatives from the selected firms within the sector were the main source of information gathered in this field survey.

Furthermore, nature of the collected data from the field survey was qualitative. Therefore, questions of the semi-structured interview were designed as an open-ended questions framework in order to allow discussions of the concepts and obtain related quality data. By semi-structured interview, it is possible to explore the details of the topics without constraints of any limited boundaries and also enabling new questions to emerge in the course of the interview with providing flexibility options (Lindlof and Taylor, 2002). With this view, the interviews with the representatives of the selected firms from the sector intended to explore the majority of the structured literature review through two main axes: the products or services utilizing ICT for Energy Efficiency and operational processes in production or supply of ICT-empowered products/services enabling energy efficiency.

Moreover, questions of the interview are designed to include following categories structured from the literature: On the products or services utilizing ICT for Energy Efficiency axis, ICT tools and applications enabling energy efficiency; marketing; and firm strategies. On the operational processes in production/supply of ICT-empowered products/services enabling energy efficiency, activity tracking; methodologies incorporated at operational level; information on the facility infrastructure. Data collected through the field survey will be processed to reveal the current situation of Turkish Consumer Electronics Sector in inclusion of ICT for enabling energy efficiency and will be used for policy recommendations by addressing the following points:

On the products or services utilizing ICT for Energy Efficiency axis;

- *ICT tools and applications enabling energy efficiency:* to asses the types of products or services, currently being provided by the firm, that are contributing to the efficiency in energy consumption, to assess the types of products or services that are specifically designed to provide energy efficiency gains and to explore the methodologies or approaches that these products utilizes.
- *Marketing:* to determine the overall market shares of products/services

provided, to gather information on the demand trends and to assess the major problems in promotion activities.

- *Firm strategies:* to identify future plans of the firms in research and development investment, to assess short-term strategies for production and marketing, to explore firms' strategies against adverse impacts of ICT utilization in energy efficiency such as rebound effects.

On the operational processes in production/supply of ICT-empowered products/services enabling energy efficiency:

- *Activity tracking:* to assess the incorporation of Life Cycle Assessment tools, and carbon footprint tracking activities.
- *Methodologies incorporated at operational level:* to determine approaches and methodologies on the production line or in service providing for ICT utilization and in dematerialization strategies (industrial automation practices, smart logistics, e-commerce, e-work, etc. …).
- *Information on the facility infrastructure:* to gather information on the types of ICT tools and applications for enabling a smart building that have been installed throughout the facility.

Collection of data followed by a procedure for processing of the data to provide input for a reliable analysis as follows:

- Meeting notes and interview transcripts were organized according to their relevancy to the structured categories of the interview.
- Irrelevant and extra information were identified and extracted from the bulk.
- Information is categorized regarding the structure of the topic.
- Data regarding the structured SWOT discussion study tabulated and summarized.

In the next chapter, hypothesis defined previously will be tested according the qualitative analysis of the results of the field survey in coherence with the structural framework of the thesis. Policy recommendations will be proposed by identification of the needs, goals and definition of policy instruments as a final part of our case study.

CHAPTER 4

RESULTS

In this chapter, validity of the hypothesis of our thesis will be tested in accordance with the results of the field survey for the case study undertaken in our thesis work for Turkish Consumer Electronics sector. Results of the field survey are presented in consistency with our structured framework regarding concepts of ICT tools and applications enabling energy efficiency, dematerialization and rebound effects presented in the literature review of this thesis.

This chapter will very briefly present general information about the Turkish Consumer Electronics sector followed by the short descriptions and background information of the selected firms within the sector. After building a descriptive section for information referred above, detailed analysis of the interviews and meetings conducted in field survey will be presented.

Furthermore, outcome of this chapter will provide the prominent information towards designing the policy recommendations along with policy needs, goals and tools in regard with ICT for Energy Efficiency concept.

4.1 CONSUMER ELECTRONICS SECTOR IN TURKEY

This section briefly gives background information on consumer electronics sector in Turkey and the top three major firms within this sector. Following part was adapted from the quarterly Turkish Home Appliances and Electronics Industry Report by Investment Support and Promotion Agency of Turkey published in July 2010.

According to finding of the report, Turkey has become one of Europe’s leading home appliances manufacturers. Specifically, the white goods sector such as the manufacturing of refrigerators, washing machines, dishwashers and ovens provides jobs for 2 million and has a production capacity of more than 25 million units per annum, which is the second largest capacity in Europe after Italy

According to Economist Intelligence Unit (EIU), the market demand for home appliances and electronics is expected to continue its growth in Turkey between 2009-2013. The expected compound annual growth rate (CAGR) for electrical appliances and white goods is 10 percent whereas the highest growth is expected in household audio & video equipment with a CAGR of 12 percent.

Report states that the expected growth is a combined result of the growing population and disposable income, together with a trend towards smaller households that may increase spending on home appliances. Arcelik, Vestel, and Bosch Siemens Home Appliances Group (BSH) are the main home appliance producers ranking in the Istanbul Chamber of Industry (ISO) 500 list in Turkey (See Table 2 below). Regarding that view, the top three manufacturers of the sector were selected to investigate under our study as our sampling group.

Table 2 Main Players in Turkey's House Appliances and Consumer Electronics Industry, 2009

Company	**Sales (*) (TRYmn)**	**Sales (US$mn)**
Arcelik	6,972	4,511
Vestel	4,640	3,002
Bosch Siemens Home Appliances Group (BSH)	2,292	1,483
Indesit	222	143
Casper Computer	198	128
Ihlas Home Appliances	100	65
Kumtel	100	65
Arzum	72	46

Source: ISI&Capital IQ, Note (*): 2009 USD/TRY average rate: 1.5456

One of the important findings of the report was that changes in consumer behavior are the main reason for the growing demand for replacements. For example, energy-efficient products are becoming more attractive by decreasing costs. Thus, consumer expectations are changing in direction towards new products using less energy and water.

When we look at the results presented in the report on the global market position of the sector, it can be seen that Turkey's export volume in home appliances has been increasing through the years 2006-2008; however, there has been a decrease in 2009, due to the global economic downturn. It is stated that, Turkey mainly exports home appliances to Europe and the UK is the largest importer of Turkish home appliances but France, Germany and Italy are also substantial importers.

Report concludes that to compete globally, mature markets are investing in R&D for newer technology and the invention of new products. Predictions from the report are showing an increasing trend in the sector globally for these investments and this trend is also applicable to Turkey.

This section will be followed by brief description of the selected firms for the field study by presenting main characteristics of the firms. Information presented below mainly adapted from firms' own presentations and from the representative at the meetings conducted for the field survey.

4.1.1 Arçelik A.Ş

Arçelik A.Ş. was founded in 1955, offering goods and services globally with 11 production facilities in Turkey, Russia, Romania and China. The firm work with nearly 3600 dealers and 600 after sales service points, Arçelik is among the largest services network in Turkey, servicing in white goods, LCD TV and air conditioner markets. Arçelik A.Ş. is expending its market share by entering new export markets in Western Europe and particularly in the U.K. and Romania.

Within their strategies, the firm adopts a sustainable development approach focusing on protecting and sustaining the environment and natural resources in all operations. Firm reveals its capacity in efficiency and protection issues by stating that it keeps environmental effects under control during a product life cycle through processes that begin at the design stage, conducting R&D and developing designs to that end. According to firm, ultimate goals of their business can be defined as to develop and market products that are resource and energy efficient, technologically innovative in design.

Arçelik incorporates Total Quality Management, Environmental Management, Occupational Health and Safety Management system that ensures certain advantages to the firm. Within these systems, Arçelik carries out projects in cost reduction, quality, and process improvement.

Furthermore, Arçelik R&D strategies include creating its own products and technology by increasing engineering strength, invested in human resources, established partnerships, and its own laboratory capabilities. However, current R&D efforts focused on product development according to meet the requirements of global structure such as environment friendly, ensuring comfort and customer satisfaction and comply with standards of the future. Moreover, in carrying out its R&D activities, Arçelik collaborates with local and international universities, suppliers, research organizations and institutes.

Moreover, Arçelik follows up the development closely to comply with EU directives as well as national regulations to ensure that its products comply with all applicable regulations during their entire lifecycle from design to recycling.

4.1.2 Vestel A.Ş.

Vestel A.Ş. provides goods and services in the white goods and information technologies fields globally including marketing, R&D activities, software development and wireless services. The firm employs 12000 employees extending to 60000 people with its subcontractors. Product range is divergent along OEM goods, LCD TVs, digital TV receivers and white goods. Vestel production facilities are located at Manisa, İzmir and Alexandrov Russia.

In R&D strategies of Vestel, goals set as ensuring growth with sustainability and increase their marketing shares in global export markets. To this end, Vestel invests in R&D activities and deployed R&D centers in Manisa Vestel City, İstanbul İTÜ Technopark, ODTÜ Technopark and deployed two more in the U.K. and Hong Kong.

Producing its own products and technology is the ultimate goal within their R&D strategies. Moreover, in the aim of becoming one of the leading firms globally at the consumer electronic sector, Vestel keeps tracking of environmental and quality monitoring and management activities all through their operations, production lines and products.

Moreover, Vestel incorporates Total Quality Management, Environmental Management, Occupational Health and Safety Management systems that ensure compliance with the regulations of the legislative frameworks. Within these systems, Vestel considers waste reduction, energy efficiency, reuse and recovery options, and protection of natural resources during product design and develop operations of R&D activities.

4.1.3 Bosch Siemens Home Appliances Group (BSH)

BSH works with 4000 associates, 500 at the Headquarters in Istanbul, 2800 at Çerkezköy production complex and 400 at regional offices in Ankara, Izmir and Samsun with its 12 brands and 41 production facilities. Product range consists of white goods and home appliances.

The concepts of innovation, quality, convenience and energy efficiency are the top priorities in BSH's business model. Following with standards procedures, firm possess the Total Quality Management, Environmental Management and Occupational Health and Safety Management systems as a global requirement in compliance with the regulations.

BSH's environmental strategies are reported to be consistent with the concepts of sustainable development and manufacturing. Efforts have been made continuously towards reducing waste streams in both manufacturing facilities and office premises. Moreover, environment-friendly product development is among the priorities of their R&D strategies. In order to achieve that R&D activities are directed through working on sustainability in manufacturing and product design.

Cooperation with universities is also an important part of BSH's R&D activities. BSH is running programs with Istanbul Technical University (ITU) for both undergraduate and graduate students. As reported, BSH develops strategies in their R&D strategies with these programs by encouraging the ideas and research of young designers and engineers that would lead to the development of new solutions for the sector. Moreover, BSH systematically increases the labor power required for firm's R&D activities and currently 108 employees with a 24% increase with respect to year 2009 statistics.

4.2 ANALYSIS AND RESULTS

Above review shows that all selected firms for the field survey are the main players in the Turkish Consumer Electronics sector. Thus, they possess the required representative qualities for the sector with their high impact on the topic. All firms have similar approaches in their R&D strategies and; thus, claiming a significant potential for technology development.

This section will present the analysis of the field survey and the testing phase for our hypothesis. Findings will be further used for policy recommendations in the direction of capacity-building initiation on ICT for Energy Efficiency topic for the selected sector.

4.2.1 Analysis and Results of the Field Survey

In this thesis, potential of ICT utilization through achieving energy efficiency presented and the topic was investigated within the major firms from the Turkish Consumer Electronics Sector. Findings from the analysis of the collected data by field survey conducted will be used to test the hypothesis of our study and in designing the policy recommendations.

Detailed analysis and results of the semi-structured interview conducted in the field survey to the selected firms from the sector is presented below according to our categorization of the semi-structured interview context. Moreover results of the structured SWOT discussion study done by the firms will be presented followingly.

Regarding the products or services utilizing ICT for Energy Efficiency axis:

- *ICT tools and applications enabling energy efficiency:* In questioning the types of products/services utilizing ICT tools and applications in enabling energy efficiency that are currently provided within the domain of selected firms from the sector, no specific responses were given from either Arçelik A.Ş., Bosch Siemen Home Appliances Group or Vestel Elektronik A.Ş. After elaborating further on the topic, they stated that they are currently producing energy efficient goods; however, they indicated that inclusion of the technology for efficiencies gained through utilization of ICT tools and applications are at a very limited level. ICT integration is limited merely to information support rather then direct energy efficiency. Representatives report that due to increasing energy efficiency demands for products from the global legislative bodies, only sensor-based electronic power conversion, drive controls and switches are the technologies that are implemented to the goods so far. Furthermore, the responses revealed that none of the firms produce ICT-empowered products for directly enabling energy efficiency.

- *Marketing:* In assessing the market shares of these products/services, since each firm has a few products that incorporate limited ICT-empowered technologies; they stated that their shares are insignificant compared to their other products on the market. They indicated that there is an increasing trend towards energy efficient products; however, there is no awareness in the market towards ICT-enabled technologies in achieving efficiency gains. Moreover, each firm stated that they can utilize technologies such as networking adaptability to goods or software enhanced home automation systems but both current infrastructure and possible initial high costs would prevent success in promoting these goods regarding the situation in Turkey.

- *Firm strategies*: In examining the future plans in developing new products or services by utilizing ICT tools and applications for achieving energy efficiency, each firm clearly stated that there no current plans developed so far for this technology adapted to their production strategies. However, they stated that they are currently following the global trends in energy efficiency according to current intense requirements from the legislative framework affecting global market. On the other hand, when we questioned the fields that are urgently need enhanced efficiency in energy intensity mitigation, Bosh Siemens House Appliances Group (BSH) and Arçelik A.Ş. stated that in power generation, manufacturing and logistics there should be immediate measures with promising benefits from the concept of utilizing ICT for energy efficiency. Vestel A.Ş. also included buildings and transportation. Moreover, none of the firms presented sufficient knowledge on the concept of rebound effects. After discussing on the topic further, Arçelik A.Ş.

approached the concept more sceptical than the others stating that regarding the current market dynamics and growth strategies of the firms would not consider these effects unless there are certain restrictions in going to market such as legal obligations or regulatory frameworks. On the other side, BSH and Vestel A.Ş., optimistically approached the concept stating that a holistic approach to energy efficiency issue would be more sensible even regarding the rebound effects considering the environmental policy of the firms.

On the operational processes in production/supply of ICT-empowered products/services enabling energy efficiency:

- *Activity tracking:* Regarding tracking the carbon footprint of the activities conducted within their domain, Arçelik A.Ş. and Vestel A.Ş. claimed that they are keeping tracks of their carbon footprint; however, Bosh Siemens Home Appliances Group (BSH) stated that there no activities regarding monitoring of carbon footprint. Although, some of the firms calculate and log their carbon footprint, they reported that there are no ICT utilized tools specific for this duty such as software packages. Similarly, Life Cycle Assessment (LCA) methodology claimed to be incorporated by Arçelik A.Ş. and Vestel A.Ş. but used in a very limited way without utilizing any software packages as well. BSH on the other did not report any activities regarding LCA methodology.

- *Methodologies incorporated at operational level:* In questioning the ICT utilization and dematerialization techniques used through the production line or service providing, each firm reported some level of methodologies that are incorporated; however, use of these activities, as reported, mainly for their functionality rather than being used for achievements through energy efficiency. All firms investigated utilizes industrial automation, computer aided design, and at some level e-commerce and teleworking. However, in terms of smart logistics they did not provide any information since logistics activities are mainly outsourced within these firms. Moreover, high-level design and test techniques such as utilizing advanced virtual reality technology in modelling, simulation and testing currently is not available within the interviewed firms.

- *Information on the facility infrastructure:* In assessing the “smart” capabilities of the facilities and buildings within the firms’ domain, we questioned the ICT tools and applications that have been installed throughout the facilities. Responses were mainly on the use of energy efficient equipment such as energy efficient lightening, but none of them reported related ICT tools and applications that are used for enabling smart buildings.

Following will present the outcome of a structured SWOT discussion study on the ICT for Energy Efficiency topic conducted during the field survey at the meetings with the selected firms from the sector (See Table 3.). In each meeting after the discussion sessions, we asked representatives for defining strengths, weaknesses, opportunities and threats of utilizing ICT through enabling energy efficiency in Turkish Consumer Electronics sector. This analysis does not represent a full SWOT study considering the circumstances of limited time that we had for the meetings. Therefore, it is only represented here the general opinions and thoughts of interviewed representatives from the firms regarding their comprehension on the topic and their general background. Hence, it is structured according to the reasons referred above. Following table presents the combined and overall view of the SWOT done by Bosh Siemens Home Appliances Group (BSH), Arçelik A.Ş. and Vestel A.Ş.

Table 3 SWOT discussion study

Strengths	*Weaknesses*
• Strong technical capacity • Good accordance with global policies in quality assurance and environmental protection • Investments in R&D	• Lack of comprehensive standards and methodologies • Lack of working legislative structure • Lack of awareness
Opportunities	*Threats*
• New market opportunities • Increased productivity • Increased sustainability	• Possible higher costs • Decreasing consumer demands due to slow recovery from the stagnant economy • Possible rebound effects

Regarding the above view, it can be seen that although firms has the required technical capacity and investment opportunities, lack of awareness is the prominent weakness of the sector regarding the ICT utilization potential in energy efficiency. Since there are no universally accepted methodologies and comprehensive standards on the issue and despite the fact that all firms are strictly following global policies on quality assurance and environmental protection, there are no further requirements for them in order to compete successfully both in global and in domestic markets. In addition to that lack of working legislative structure also prevents motivation towards investing in such technologies since legislative restrictions and obligations are among the main drives of the investment strategy development in general.

Furthermore, firms are foreseeing new market opportunities, both globally and domestically, as new products developed and demanded by the consumers. However, as discussed by the representatives, initial increase in the internal costs for the first marketed products would create a decreasing customer demand considering the global economic conditions and possible shifting of consumer behaviour towards primary needs. On the other hand, they expect increased productivity and increased sustainability with the potential capacity of ICT utilization. Moreover, concept of rebound effect was seen as a threat in general, but not specifically in possible impacts on the overall energy efficiency gains. Because, concerns of the firms converge mainly at the point that none of them are willing to sacrifice their growth rates unless a more realistic approach comes out of a commonly agreed discussion on the rebound effects.

4.2.2 Testing the Hypothesis

After reviewing the literature on ICT for Energy Efficiency concept we have structured our case study and formulated a field survey according to theoretical background. Considering the results of the field survey we observed the current situation of the Turkish Consumer Electronics sector regarding our framework and it revealed the selected firms opinions and views on the topic under discussion. According to analysis of the selected firms, similar responses were given from the representatives and it can be concluded that they share almost the same level of awareness in our topic. Regarding the findings from the analysis of the firms from the sector, we will move to test the hypothesis of our thesis study defined previously.

The hypothesis is as follows:

Utilization of ICTs can help improving energy efficiency in consumer electronics sector in Turkey.

In testing of this hypothesis, we will use results of the semi-structured interview that we have conducted with the selected firms from the consumer electronics sector. The theoretical background for the hypothesis has been given in the previous sections of this thesis.

Our results indicate that currently major producers in Turkish Consumer Electronics sector utilizes ICT tools and applications within a very narrow spectrum of their products with a very limited technology regarding the scope of our reviewed literature on ICT for Energy Efficiency. In addition to that, this incorporation of ICT is mainly done due to the global market trends without the awareness of the concept thoroughly. More specifically, in domestic market the shares of these products are reported as insignificant compared to conventional goods. Thus, current energy efficiency gains mostly achieved from conventional energy efficiency approaches, which utilize general technical and hardware-oriented enhancements in goods.

Moreover, none of the firms under investigation representing the sector provides ICT-empowered products/services that directly enable energy efficiency. Although there is a reported capacity by the representatives interviewed for providing ICT-enabled technologies such as network adaptability to goods and full software-empowered home automation systems, the results indicate that current infrastructure and possible increase in the initial costs for these products threatens consumer demand trends.

Furthermore, firms representing the sector under investigation do not have current plans and strategy development initiatives on utilizing ICT for energy efficiency through ICT tools and applications. However, current global approaches and methodologies in energy efficiency are followed closely due to the requirements from the global legislative structures affecting the markets.

A sceptical standing is dominant on the concept of rebound effects in the sector. In general, due to the complex nature of the concept, firms are expecting more realistic approaches in strategy development for rebound effects. Firms tend to oppose the idea, which threatens their growth rates according to their perception of rebound effect. However, they agree on the holistic approaches that embrace all factors included in developing strategies for achieving energy efficiency

Carbon footprint tracking is reported that mainly it is performed throughout the firms operations; however, it is indicated by the results that there are no ICT enabled techniques incorporated in these activities such as software packages designed for the specific purpose of carbon footprint tracking. Same situation is also valid for Life Cycle Assessment (LCA). It is in operation without aided by software applications.

On the production line or service providing, ICT applications and dematerialization techniques such as industrial automation, computer aided design, e-commerce and teleworking are widely incorporated. However, because of the lack of awareness on the subject of our study, these activities are used for their functionalities rather then their potential for energy efficiency gains.

In terms of smart logistics concept, firms do not have any knowledge about the issue since mainly it is an outsourced operation within their domains. In addition, design and test operations, minimizing material and energy intensity techniques such as virtual reality used in modelling, simulation and testing is not currently incorporated within their practices.

“Smart” capabilities of the facilities and buildings where the firms practice their major processes and operations do not exist according to our structured literature review framework. However, energy efficient equipment such as energy efficient lightening is widely used among the firms.

Regarding the above conclusions, the current situation of the represented firms and the sector reveals that there is a limited inclusion of ICT in the aim of achieving energy efficiency gains. As we noted from the meeting sessions, the prominent factor causing this instance is the lack of awareness. Representatives stated that they are not familiar with the ICT for Energy Efficiency concept; however, as we questioned through the guidance of our structured literature review it is revealed that some of the practices of ICT for Energy Efficiency concept are currently incorporated within their domains. However, as it can be seen from the analysis the inclusion remains at very low levels, particularly due to the preference of functionality over energy efficiency.

On the other hand, as discussed in the profiles of the firms and referring to our conducted structured SWOT analysis, each firm claims to have a sufficient capacity regarding their R&D activities and following the global contexts on the recent development trends. This capacity needs to be further enhanced and fostered towards utilization of ICT in order to approach the enabling effects of ICT in energy efficiency.

To conclude, regarding this view our argument is opposed by the current situation presented since there is only limited contribution of ICT in the sector and the concept is unknown for now. However, initiation of awareness increase together with strengthening the R&D activities and establishing continuous links with the global context can support our argument strongly as a first step by creation of referred initial conditions.

Moreover, these issues will be addressed in the policy recommendation section in the next chapter. Regarding the necessary creation of these initial conditions, we will shift our ideas through directing the policy proposals focusing on these issues.

CHAPER 5

CONCLUSION

In this chapter, structured framework of the thesis will be connected with the conducted field survey. Literature review presented in this study provided the main characteristics of the concept of ICT for Energy Efficiency and supplied the theoretical background for investigating the topic in our case study conducted for Turkish Consumer Electronics sector. Field survey presented the general characteristics of the interviewed firms representing the sector and guided us through mapping the current situation of ICT inclusion in the sector. Regarding the profiles of the firms and achieved results, we will assess policy needs, policy goals and will propose policy instruments in the context of policy recommendation. Therefore, we intend to contribute in increasing the awareness on the topic and to initiate first attempts for preparing the sector to upcoming trends in energy efficiency issues. This chapter will be followed by final concluding remarks and suggestions for further research.

5.1 POLICY RECOMMENDATIONS

Analysis of selected firms, Bosch Siemens Home Appliances Group (BSH), Arçelik A.Ş. and Vestel A.Ş, will be used in this section in identification of policy needs and formulating policy goals and policy instruments accordingly.

According to our analysis, we concluded that the prominent finding of our field survey is that there is no awareness on the concept of ICT for energy efficiency among the interviewed firms representing the sector. Moreover, it is identified that recent developments and newly emerging trends are not followed closely. Consequently, we concluded that Turkish Consumer Electronics sector does not incorporate the full potential capacity of ICT in enabling energy efficiency according to our structured theoretical background provided by the literature review.

Following this situation, although there is stated sufficient technical potential to produce ICT-enhanced products/services for enabling energy efficiency, firms do not initiate programs and develop strategies for the issue. Regarding these missing elements identified with the results of the field survey and the theoretical background structured specifically for the ICT for Energy Efficiency concept, a necessity to take action through policy interventions sets the scene for utilizing the referred capacity of the sector. Thus, we intend to enable the first steps towards building a capacity on the utilization of ICT for energy efficiency in Turkish Consumer Electronics sector.

Policy needs

According to our results we identified the following areas that need policy intervention in Turkish Consumer Electronics sector in order to achieve the ability to use its full potential on the ICT for energy efficiency issue.

- Awareness increase on ICT for Energy Efficiency concept
- Following the global structure and recent developments on ICT for Energy Efficiency
- Enhancement of R&D activities through exploring the potential of ICT for Energy Efficiency

With assessing and addressing these areas, objective of making the initial contribution for capacity building through achieving the goal of enabling of ICT for Energy Efficiency in Turkish Consumer Electronics sector would be accomplished. Furthermore, having been completed a sufficient background and being an active contributor to the field, the sector would be able to benefit the advantages of putting ICT to a focal point in achieving energy efficiency gains.

Policy goals

In the literature review, we addressed the advantages of ICT utilization in enabling energy efficiency through many ways that the sector could adapt and benefit from it by developing new strategies. Therefore, overall objective of the policy goals proposed here is to enable the sector to initiate and develop the background for ICT for Energy Efficiency and to be able to become an active contributor to the ICT for Energy Efficiency field by utilizing its sources. Thus, the sector would become equipped to benefit from the potential of ICT in energy efficiency. In order to achieve overall objective, certain goals should be defined and accomplished.

Therefore, considering the addressed policy needs, the following policy goals can be formulated:

- Increasing the awareness on ICT for Energy Efficiency concept
- Establishing connections with the global context on ICT for Energy Efficiency; encouraging participation to global events; promotion of information and know-how exchange.
- Strengthening the R&D activities through exploring the potential of ICT in energy efficiency; enhancing university sector cooperation

Policy instruments

Policy instruments are the tools and guided paths to achieve policy goals. After addressing the needs and goals we propose the following according to the results of the field survey and our framework.

a) Awareness on ICT for Energy Efficiency is the top priority factor in the sector in order to initiate actions toward achievement on energy efficiency. To increase the level of awareness on ICT for Energy Efficiency in Turkish Consumer Electronics sector we propose the following:

- Organizing events seminars, training programs, workshops on the ICT for energy efficiency concept within the firms and within the sector with participation of both high-level managers, other staff and NGOs like Turkish Association of Electronics and Information Industries (TESID) would help accumulation of knowledge and dissemination of information.
- Establishing platforms or forums within the sector that firms could register and share their experiences and discuss certain issues to enhance the communication of the topic. This can be in the form of a web portal.
- Organizing exhibitions and fairs within the sector where firms can meet and present new products or promote new services as well as inviting firms, initiatives, organizations that invest in ICT for Energy Efficiency issue from other countries to present and share knowledge.

b) Establishing continuous connections with the global context on ICT for Energy Efficiency is the vital element for the sector in order to keep in line with the recent developments and to be able to take role in making information exchange and know-how transfers among the top players by establishing and also participating in joint platforms. To ensure this we propose the following:

- Encouraging firms within the sector to register and get involved in certain web-based portals and forums such as European ICT Network for Energy Efficiency (ICT21EE), ICT for Energy Efficiency Forum (ict4ee forum), or REViSITE (Roadmap Enabling Vision and Strategy for ICT enabled Energy Efficiency, Digital Europe forum. Therefore, accumulation of fast and direct knowledge could be achieved continuously by sharing experiences, participating in joint project development competitions, and so on.
- Encouraging firms to attend regular events that are being organized globally by several bodies where certain policy debates, sector needs, problem discussions are held such as regularly organized High Level Event on ICT for Energy Efficiency by European Commission.

c) Strengthening the R&D activities within the sector to explore the potentials offered by ICT in energy efficiency should be a high priority in strategies developed by the firms and the sector. In order to enhance the R&D activities towards utilizing their full potential on the topic we propose the following:

- Fostering university-firm collaboration through designing and developing case studies, best practices, or organizing award-based project competitions on ICT for Energy Efficiency issue.
- Enabling mobility of researches between both university and firm by project based cooperation or joint-research programs.
- Encouraging R&D personnel to conduct and participate in developing publications on ICT for Energy Efficiency in cooperation with universities or within the platforms that could establish in the sector
- Encouraging firms to employ MS or PhD students by offering part-time jobs and also cooperating in their thesis studies or motivating them to study on ICT for Energy Efficiency concepts according to firms' R&D activities.
- Encouraging firms to develop and deploy such technologies by public sector with initiatives such as tax exemptions.

5.2 CONCLUDING REMARKS

Main purpose of this thesis is to depict the current inclusion of ICT empowered methodologies and approaches in Turkish Consumer Electronics sector and to assess the level of awareness about ICT for Energy Efficiency concept on the selected firms. Hence we intended to argue on whether uutilization of ICT could help improving energy efficiency in consumer electronics sector in Turkey. To achieve these purposes we structured a general framework from the literature consisting of brief theoretical and practical discussions on enabling role of ICT in energy efficiency by application of technological enhancements and through dematerialization, carbon footprint of ICT and rebound effects. This structured framework used as a roadmap for our field survey and the results of the conducted field survey provided the inputs for policy recommendation design.

Moreover, results of the field survey used in testing the validity of our hypothesis given previously. The main findings of the field survey can be summarized as:

- There are no products or services directly enabling energy efficiency by utilizing the ICT application or methodologies in the sector.
- There is a limited contribution of ICT in energy efficiency by utilizing basic technologies such as on information support or sensor technologies.
- Overall share of these specific ICT-empowered product or services is insignificant.
- Firms do not incorporate strategies regarding ICT for energy efficiency
- Dematerialization techniques are also limitedly incorporated in the firms and their functionality suppresses its gains in energy efficiency according the perception of the firms.
- Management and process support utilize basic production and design instruments, high-tech support such as virtual reality in simulation, modeling and testing is not incorporated.
- Carbon footprint activity tracking is not processed sufficiently and does not incorporate any ICT support.
- Rebound effect concept is not an acknowledged topic by the sector and they do not consider the possible impacts of the concept.
- Overall, there is a lack of awareness on ICT for Energy Efficiency concept.

Therefore we argued that:

- If initiatives begin towards increasing the awareness on the ICT for Energy Efficiency, utilizing the potential strength of R&D capacities on the topic under study and deployment of bridges between the sector and global context on the development of ICT for Energy Efficiency, utilization of ICT can help improving energy efficiency in consumer electronics sector in Turkey.

Followingly, the results of the field survey shaped the ideas for policy recommendations. First we addressed the issues that need policy intervention, secondly, we defined policy goals and lastly, we proposed policy instruments in order to achieved defined goals. Lack of awareness and the potential capacity of R&D strength of the sector drove the proposal procedure as we identify needs, goals and policy instruments. The summary of the identified points is presented in Table 4.

Table 4 Summary of Policy Recommendations

policy needs	Awareness increase on ICT for Energy Efficiency concept
	Following the global structure and recent developments on ICT for Energy Efficiency
	Enhancement of R&D activities through exploring the potential of ICT for Energy Efficiency
policy goals	Increasing the awareness on ICT for Energy Efficiency concept
	Establishing connections with the global context on ICT for Energy Efficiency; encouraging participation to global events; promotion of information and know-how exchange.
	Strengthening the R&D activities through exploring the potential of ICT in energy efficiency; enhancing university sector cooperation
policy instruments	a) Awareness increase on ICT for Energy Efficiency: • Organizing events seminars, training programs, workshops on the ICT for energy efficiency concept within the firms and within the sector • Establishing platforms or forums within the sector. • Organizing exhibitions and fairs within the sector

Table 4 continued.

	b) Establishing continuous connections with the global context on ICT for Energy Efficiency: • Encouraging firms within the sector to register and get involved in certain web based portals and forums. • Encouraging firms to attend regular global events that are being organized by various bodies
	c) Strengthening the R&D activities within the sector to explore the potentials offered by ICT in energy efficiency: • Fostering university firm collaboration • Enabling mobility of researches between both university and firm • Encouraging R&D personnel to conduct and participate in developing publications on ICT for Energy Efficiency • Encouraging firms to employ MS or PhD students by offering part-time jobs and also cooperating in their thesis studies or motivating them to study on ICT for Energy Efficiency concepts according to firms' R&D activities • Tax exemptions by public sector for the development and deployment of such technologies.

In conclusion of this thesis, we can state that in order to enable ICT for Energy Efficiency in Turkish Consumer Electronics sector the following critical issues should be addressed and promoted regarding proposed policy recommendations and policy instruments: increasing awareness on the ICT for Energy Efficiency concept, strengthening the R&D activities along with including strategies for exploring the benefits of utilising ICT for energy efficiency, and establishing a continuous link between the sector and the global structures aiming at keeping in line with the recent developments on the topic.

5.3 SUGGESTIONS FOR FURTHER RESEARCH

Our study is designed as an initial attempt for debating on ICT for Energy Efficiency topic. We have structured our thesis as a case study on Turkish Consumer Electronics sector; since, we can observe most of the discussed issues on the structured literature review have applications and examples on the selected sector which has a significant impact and share on the market as in the case of Turkey.

However, similar studies should also be conducted in various sectors all-contributing to the energy intensity issues. As we stated before, this attempt was an initial step towards searching the possibilities of ICT that can offer in achieving energy efficiencies. Therefore, the scope of following studies could be enhanced to cover more broader topics as well as discussing opposing views on the subject as debates goes on further.

We have approached the topic from enabling role of ICT; however, as many studies shows that counter arguments could be developed and discussed on the issue. Particularly, rebound effects concept is an interesting topic that discusses the adverse impacts of increasing efficiencies and hence discussions on this issue can further be elaborated.

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APPENDIX A

Heading, Ventilation and Air Conditioning (HVAC)

Passive and active thermal wall insulation

According to Bavarian Center for Applied Energy Research the next step to ICT-enhanced smart building insulation is based on the vacuum insulation panel technology. A similar approach is used in the application of Phase Change Materials (PCMs) for thermal energy storage in walls or building insulations.

The idea is to regulate the in-house temperature by controlling and actively switching the thermal conductivity of the panels. ICT-based sensors and control devices are needed in such a system to achieve efficiency. The ICT support system comprises of outside and in-house temperature sensors, possibly internet-based weather information, and sensor/actuator control system with respective communication protocol. The ICT applications support the time-critical and demand- specific control of the insulation panels, which in turn determines the overall energy efficiency and lifetime quality of the passive HVAC system.

Switchable mirror film on windows

The Japanese National Institute of Advanced Industrial Science and Technology (AIST) announced in 2007, that it had developed a light-control mirror film, which controls sunlight efficiently and helps increase security by switching between reflective and transparent states with very little voltage. The institute reports that the system was successfully built on a 100-micrometer-thick film. Moreover, it can be produced as a thin film, and can be applied to both glass plates and flexible substrates such as plastic. Just by applying the film to existing window glasses, the amount of heat or cooling load inside buildings or cars can be controlled at the flick of a switch.

The new mirror film operates as an electro-chromic system and can be electrically switched between reflective and transparent states by applying a voltage of a few volts. The film is made entirely of solid materials, and thus offers an easy handling.

Temperature monitoring and heating control

The following examples of residential HVAC controlling units are only a small part of available product solutions in the market. The “Room Temperature Modulation” is a technology used in all Buderus condensing boilers and control units. The ModuLink 250 RF is a wireless thermostat and programmer designed especially for Buderus domestic condensing boilers. This unit has independent heating and hot water control, built-in frost protection, a holiday function, and up to 6 different switching points allowing the user total control of their heating system. This energy saving technology controls the output of the boiler according to the temperature of the air in the room, rather than measuring the flow temperature in the boiler. This means the boiler can react almost instantaneously to the smallest temperature fluctuations, adjust its output accordingly, and maintain comfort levels in the room.

Integrated cooling of ICT infrastructure equipment

An example for ICT-enhanced condition monitoring and air condition management is the Thermal Zone Mapping (TZM) in conjunction with the Dynamic Smart Cooling (DSC) technology developed by Hewlett Packard (HP). The TZM enables customers to see a three-dimensional model of exactly how much and where data center air conditioners are cooling. The DSC solution is based on real-time air temperature measurements from a network of sensors deployed on IT racks. These advanced ICT hardware and software solution continuously adjusts air conditioning settings for demand-oriented (optimal) cooling. HP argues that customers can reduce data center cooling energy costs by up to 45% by using Thermal Zone Mapping and Dynamic Smart Cooling.

Integrated control of clean room conditions

The Japanese Yamatake Corporation, one of the building automation solution providers, developed InfilexTMCR, an energy-saving controller for clean rooms. Yamatake developed a programming-based predictive control based on proprietary mathematical models, which realizes fast and precise control of temperature and humidity levels. The potential benefits are substantial, with recovery of investment expected to take only one-and-a-half years. According to Yamatake Report (2007), a reduction of the HVAC energy consumption by approximately 50% can be achieved.

The German automation technology provider FESTO addresses energy saving in that respect by monitoring air consumption and flow rate for more efficient compressed air management. FESTO's GFDM monitoring system, consisting of sensors/controller, software-tool VipWin for process visualization, and a front-end-display, tracks down air leaks by constantly and automatically generated reference data. This data is used for permanent comparison, evaluation of consumption using multi-level thresholds and rend data acquisition. There is no impact on the automation process caused by GFDM, so it is applicable for retrofitting existing systems.

Lighting and Security Systems

Lighting accumulates to a considerably large portion of electricity consumption not only in the building infrastructure of the residential and tertiary sector, but also in all other industry sectors including agriculture, manufacturing, and construction (Webb, 2008)

It is also generally understood that there is a good technical improvement potential in the field of lighting. The reduction of energy consumption related to lighting follows two main approaches: one is new light sources and the other one is ICT-enhanced lighting control. The technical development of light sources is driven by the improvement of the luminescence efficiency, the quality of light, the life span, and of course the price of the lamp, as well as the power consumption and overall life cycle efficiency (Ibid).

Solid-state lamps, inorganic and organic light emitting diodes (LED/OLED), are quite new light systems that are considered the next generation of low power light source. As today's white LED reach efficacies up to 40-110 lm/W (efficiency depends on color temperature and color rendering), they are more and more used in general lighting. The power consumption is very low in mW range. LEDs are considered to have the best market potential due to an inexpensive mass production (Webb, 2008).

<u>Inorganic and Organic LED based lighting</u>

The following examples for OLED lighting are providing an overview on the solid-state lighting technology.

Seoul Semiconductor, one of the world's leading LED manufacturers, developed Acriche, the first semiconductor lighting source that can be driven directly from an AC outlet without a converter. Acriche has 35,000 to 50,000 hours of comparably longer working life. Acriche is applicable for general lighting, architectural lighting, street lighting, residential lighting (Under-cabinet), decoration lighting and sing lighting.

Osram Opto Semiconductors developed the LED lighting system Golden Dragon Oval for street lighting. Only 12 LEDs are necessary for illuminating a street from a height of 3.4 meter. The Golden Dragon Oval LED lighting source can be driven directly with 220- 230 volts and without a converter. The system develops 60 lm at 359 mA and is usually driven at 130 mA. They consume 0.35 W per LED (1 W in street lighting standard application). Similar results have been achieved with the Golden Dragon LED system for residential lighting. The replacement of a 100 W light bulb with a LED system reduced energy consumption by 82% or 34 kg CO2.

OLEDs are organic light-emitting diodes whose electroluminescent layer is composed of a film of organic compounds. They can be used in displays for TVs and cell phones but also for lighting applications. OLEDs are flat light sources and could be used in light systems with controllable color and, in future, can be made on flexible substrates (NanoMarkets, 2007).

Important research and development initiatives with respect to OLEDs are the search for more stable, higher efficiency organic semiconductors. The power efficiency of OLEDs should be improved through converging technologies that improve the electrical conductivity of the OLED transport layers. The doping material needs to be robust enough to resist cross contamination in a vacuum deposition process and does not diffuse within the OLED over time that would reduce the light generation efficiency of the OLED (BIS, 2008).

Rollex is a project funded by the German Federal Ministry of Education and Research and stands for “roll-to-roll production of high efficient light-emitting diodes on flexible substrates”. With the roll-to-roll-concept, noticeable lower coating costs are expected compared to cluster or inline concepts used for display production. The use of low- priced aluminum foils as substrate for the deposition of very efficient organic light- emitting diodes is planned as a further cost-reducing step. Aim of the project is to develop a pilot plant.

ICT-enhanced lighting control

Lighting automation is now becoming a must rather than the exception, according to an U.S. market research study funded by Ducker Research in 2003. The study found that lighting automation is being used in a majority of new construction and renovation projects in the office and school markets. This U.S. study also found that users are very interested in the advantages of controls, primarily energy savings and energy code compliance, but seek simple and low-cost solutions. (DiLouie, 2003)

Lighting can be turned on and off as well as dimmed most efficiently with a lighting control that is integrated in the building automation system (BAS). Lighting controls are devices that regulate the operation of the lighting system in response to an external signal (manual contact, occupancy, timer, light level). Lighting control is scalable from a localized manual switch up to lighting controls that are integrated in a building automation system (BAS). ICT-enhanced lighting control systems include: occupancy or motion sensors linked to a control panel, daylight or ambient light sensor linked to a control panel, timer-based lighting control (BIS, 2008).

Most desirable lighting automation technology includes standard protocols along with plug-and-play solutions and low-cost electronic dimming ballasts. Advanced controls and dimming ballasts are fields where ICT has a potential for improvement. ICT is linking the sensors with the control panels and actuators. It is the technical interface in an integrated building automation system (BAS). ICT is also providing software-controlled data processing, memory and display functionality for easy user interaction. The wireless communication option is increasing the cost effectiveness for modernizing or upgrading the lighting system (Ibid).

Occupancy and daylight sensors

The Green Light Programme gives more detailed information about occupancy sensors and daylight detecting systems. This Program encourages “non-residential electricity consumers to commit towards the European Commission to install energy-efficient lighting technologies in their facilities when it is profitable, and lighting quality is maintained or improved”.

According to this project, there are mainly three different types of occupancy detectors.

First, passive infrared (PIR) occupancy sensors: These sensors respond to the motion of infrared energy or heat produced by human bodies. They use one or more pyro-electric detectors located behind an infrared-transmitting, segmented lens. The detector's field of view is typically divided into detection zones. Lights are turned on when the sensor detects the motion of a heat source across a detection zone boundary within a defined period. Passive infrared sensors are line-of-sight devices that need an unobstructed view of motion to operate effectively.

Second, Ultrasonic occupancy sensors: These systems operate by responding to the change in reflected sound waves in a space caused by moving objects. Ultrasonic sensors operate at frequencies that are above human sensitivity (20 kHz), typical operating frequencies are 25, 30 and 40 kHz. Compared to infrared sensors they detect smaller motions and do not require a direct line-of sight.

Third, Ultrasonic-infrared occupancy sensors: These detectors combine passive infrared and ultrasonic technologies and are therefore also called “dual” or “hybrid” sensors. The light is kept on as long as the on of the technologies detects motion. Thereby, the problem of turned off lights while the space is occupied is reduced.

Other Electrical and Electronic Equipment in Buildings

The category comprises of a broad range of electrical and electronic equipment (EEE) in buildings including:

- Building equipment with large electrical drivers (e.g. elevators, escalators, automatic gates, lifting ramps)
- Building security and safety automation (e.g. fire/smoke alarm systems, security looks and intruder/motion detectors, surveillance cameras)
- White goods (e.g. refrigerators, freezer, washing machines, stoves, ovens)

Elevators and escalators

With respect to elevators, ICT finds application most commonly for maintenance and security measures in case of breakdowns. ThyssenKrupp207 provides an innovative service feature for control systems, VISTA Remote Monitoring, which monitors the performance of the elevators around the clock. The system will alert if something out of ordinary occurs or if the elevator's performance does not achieve optimum standards. A communication device, installed inside the elevator controller, relays an ongoing stream of information to a call center. Critical events are immediately forwarded to the local office where appropriate action can be taken.

Hitachi208 developed a remote monitoring system, which detects warning signs and responds before the systems actually breaks down. Invented for helping elderly or persons with a handicap, there is also a software program installed that reads information out loud from a computer screen.

As these examples show, advanced monitoring systems enable a more effective resource allocation, which can save energy. This means for instance that a service team can be scheduled according to specific maintenance demand rather than on duration based servicing plan. This can save energy because it may reduce the frequency of service tours.

With respect to escalators, Hitachi Ltd. of Japan started selling its VX Series of escalators in 2008, which features advanced functions designed for improved safety and energy savings. The standard model can operate in "eco-mode," reducing power consumption by about 13 percent by detecting the rider load based on information from the inverter controls. The escalator reduces its operational speed imperceptibly to riders. The new model also has a variety of new optional functions for energy saving not available in conventional models. These options include an automatic start system, which starts operation when a rider approaches the escalator, and a "crawl" mode that runs the escalator at a speed of ten meters per minute when there are no riders.

Security systems

Security systems are a minor contributor to the overall energy consumption in buildings. However, security systems such as smoke detectors and fire alarm systems, monitoring cameras, automatic doors and windows, as well as bell and intercom systems are important features of buildings with high requirements on reliability and accuracy (Webb, 2008).

Security systems are usually highly integrated into the building infrastructure. The application of ICT is related to sensors, monitoring and control systems. The miniaturization and digitalization of electronic components and ICT are impacting the performance, size and energy consumption of sensors, scanners, locks, cameras, and displays. In the field of building automation and security system is ICT a main driver of innovation (Ibid).

White goods

Electrical appliances such as refrigerators, freezers, washing machines, dryers, dish washer, electric stoves, microwave ovens and smaller electric cooking appliance are a source of constant or frequent power consumption.

The application of ICT in support of the functionality of large and small household appliances was also a topic in many studies. However, ICT applications have been acknowledged for these products mostly in terms of information support and less in direct energy efficiency. Nevertheless, sensor-based electronic power conversion, drive controls and switches are an integrated technology already for some time due to the growing energy efficiency requirements as a result of the implemented EU Energy Label (BIS, 2008).

For newer models, the feature “network connectivity, the communication between household appliances” becomes available. Especially for refrigerators and freezers this feature is increasingly offered. It should allow in combination with RFID on food products an online check which products are inside the device, let the device produce the shopping list or inform the user when certain items are going to expire (Ibid).

Electrical Drivers, Motors, Pumps and Fans

Electrical drivers, using advanced microelectronic solutions, have a good potential for improved energy efficiency. European Commission in collaboration with the C.E.M.E.P224 (European association of manufacturers and the European regulating body) developed a voluntary “energy efficiency” classification scheme (EFF 3 [low], EFF 2 [medium], EFF 1 [high]) based on the conversion efficiency for 2- and 4-pole squirrel cage motor. Three-phase drivers as well as permanently magnetized synchronous motors have principally lower rotor losses and therefore even better conversion efficiency.

ZVEI (2006) provides an interesting assessment of the improvement potential related to energy saving of electrical drivers (low voltage motors). Three measures are distinguished: High efficiency motors HEM (10% improvement), Electronic rotation speed control (30% improvement potential), Mechanical system optimization (60% improvement potential) The following are examples for the application of energy efficient speed controls.

One important component of an electrical drive is a frequency converter. For the speed regulation of a three-phase motor the frequency as well as the voltage needs to be changed. This is done in an electrical frequency converter, which converts alternating current (AC) of one frequency to alternating current of another frequency, and is controlled by a microcomputer and its software (BIS, 2008).

The following example provides an insight of the application of ICT in conjunction with these general technical trends.

Variable Frequency Drives

A big innovation in energy savings was the variable frequency drive (VFD). The variable frequency drive added efficiency to systems by making it possible to speed up and slow down electric A.C. motors based on demand. The age of running an electric motor full blast all day long ended when this innovation, the variable frequency drive, was first used in commercial HVAC (BIS, 2008).

Variable frequency drives work by changing the frequency of the power supplied to the motor. By changing the frequency of the power the speed can be changed. Blower fans and pumps can be modulated based on demand. Variable frequency drives need a method of control to modulate the electric motor. Some variable frequency drives have a built in controller which, when programmed, will control the motor based on a set of instructions in the program. Modern systems rely on a direct digital control system and application for this function. Based on an input variable the direct digital control system will send a signal to the drive to speed it up or slow it down depending on the direct digital control programming (Ibid).

System Automation and Power Management of Industrial Equipment

Network capability and network control are keywords with respect to directly controlled drivers .The most common bus interfaces is a 100 Mbit/s Ethernet and standard Internet protocols which allows real time communication. With respect to the hardware it is noticeable that commonly used decided logic components are replaced by field programmable gate arrays (FPGAs) which provide more flexibility in design of the hardware and the application of software. This also allows a virtual product development based on models of component (Webb, 2008).

ABB developed software for "intelligent pump control" in the frequency converter. This is an optional software tool for low voltage frequency converters of the ABB industrial drives series, which especially meets the requirements of water and waste water management, industrial facilities and other pump applications. The intelligent pump control contains six integrated pump control functions. Two of these functions are especially useful in terms of energy efficiency.

One of these functions is the "pump priority function". This function balances the operating times of all pumps in the system over a long period of time. Thereby the planning for maintenance becomes easier and the energy efficiency will be increased as the pumps operate closer to optimum operating point. An example is also an application, which has higher loads during the day. The drive can be programmed to run pumps with higher capacities during the day and smaller ones over night.

Another function is the sleep function, which increases the pressure or water level before powering down. Thereby the idle period of the pump will be increased which leads to reduced energy consumption. Additionally unnecessary starts and stops are avoided.

Electrical motor monitoring

According to a report by GE Global Research on "Distributed Wireless Multi-Sensor Technologies" electric motor systems consume about 60% of all generated electric power and 70% of all electricity in industrial applications in the United States (Sexton, 2008).

GE estimates that energy savings of 122 trillion BTUs233 (approx. 36 TWh) until 2020 can be achieved through the use of motor condition monitoring. The report is the result of a programme which main goal was "to develop wireless sensor technology that would be commercialized and adopted by industry for a various set of applications. Many of these applications will yield significant energy savings.

One example where the potential energy savings could be estimated focused on equipment condition monitoring and in particular electric motor monitoring.

Traffic management system (TMS) for elevators

A special traffic management system uses a destination control system where the user chooses its destination floor (via an alphanumeric keyboard or a touch screen) before entering the elevator. Inside the elevator are normally just displays to show the destination but no further user interfaces. The TMS uses the information on destination floor and number of people to group people travelling to the same floor, allocate the user to the right elevator and reduce the number of intermediate stops. Often these systems are combined with security systems (identification via pin codes or badges to allow access to certain areas/floors) or additional individual services such as avoiding transportation of goods together with customers (BIS, 2008).

APPENDIX B

ICT for Energy Efficiency: A Case Study in Turkish Consumer Electronics Sector
Open-ended Framework
This interview will be applied to representatives from the major consumer electronics producers in Turkey.

Arçelik A.Ş. (Beko)
Bosch Siemens Home Appliances Group (BSH) (Bosh / Siemens / Profilo)
Vestel A.Ş.

Products or Services Utilizing ICT for Energy Efficiency

1. What kind of products or services do you provide within your domain that contribute to improving mitigation of energy intensity of consumer activities by utilizing ICT tools or applications?
2. Which product or service range that you provide aims specifically at energy efficiency?
3. What kind of approaches or methodologies does these products or services incorporate in providing energy efficiency through the utilization of ICT?
4. What is the overall share of these products or services in the market in comparison with the conventional products or services?
5. How can you elaborate on the demand trends of these products or services?
6. What are the main bottlenecks in promoting these products or services?
7. What is your future plans in developing new products or services by utilizing ICT tools and applications for achieving energy efficiency?
8. How can you define your strategy in providing your products or services in the present and in the middle term?
9. What is your point of view in determining the most important focus areas that urgently needs incorporation of ICT diffused energy efficiency

solutions? (Buildings, Logistics, Transportation, Construction, Manufacturing, Power Generation, etc...)

10. What is your strategy against the Rebound Effects?

Operational Processes in production or supply of ICT empowered products and services enabling energy efficiency

1. How do you keep track of your activities' carbon footprint? Which tools do you use?
2. What kind of approaches or methodologies did you incorporate on your production line or service providing regarding minimizing your energy intensity? (smart logistics, e-commerce, e-work, industrial automation, etc...)
3. How can you elaborate on the main strategies deployed in your R&D department concerning energy efficiency?
4. What kind of LCA tools do you use? (softwares?)
5. What kind of dematerialization strategies did you incorporate at your organization? (e-work, e-commerce, computer aided design, modeling and simulation techniques, virtual reality in testing...)
6. How can you describe your organization as a smart building? Which tools or applications did you install throughout the facility? Smart metering, smart lightening, automation systems, etc...