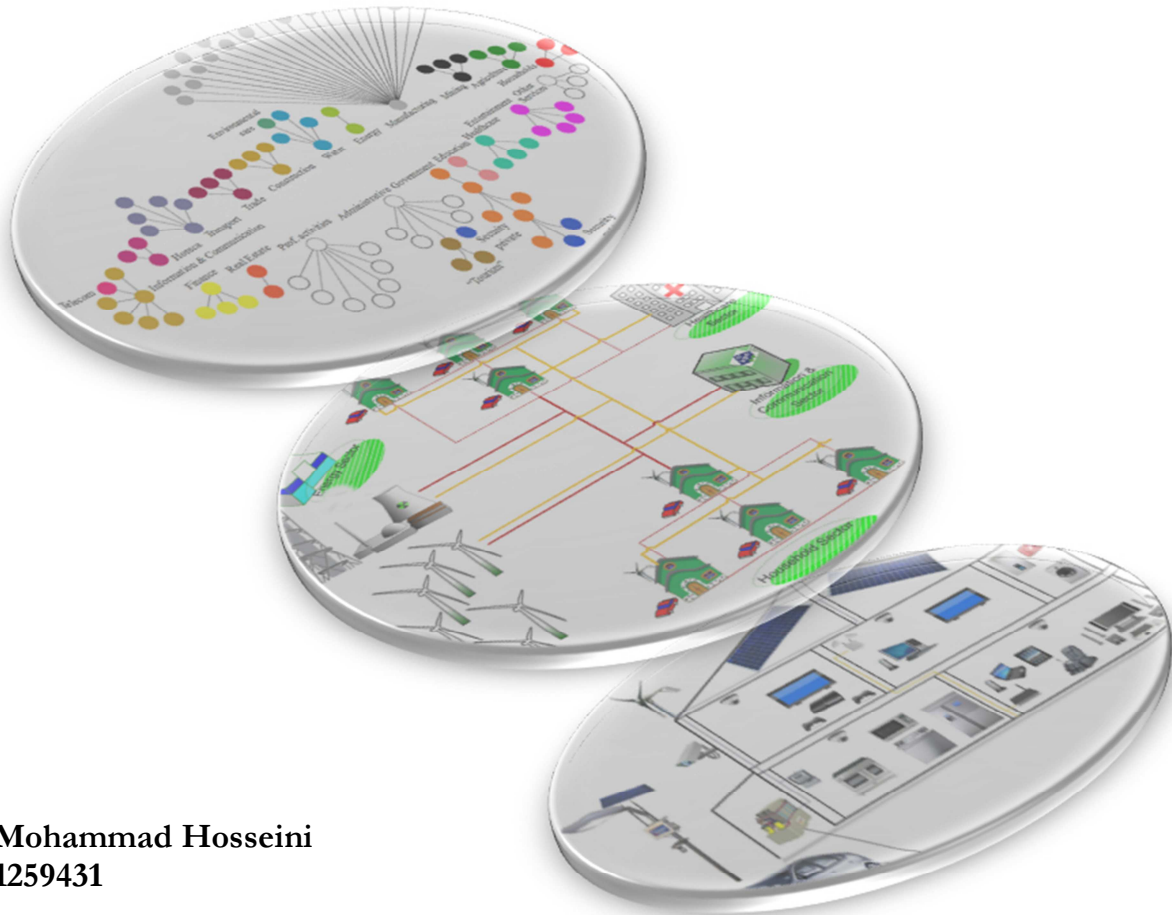


# Telecom and Energy, vital sectors enabling Smart Living

## Master of Science Thesis

Faculty Electrical Engineering, Mathematics and Computer Science  
Network Architectures & Services (NAS) Group  
Trans-sector Innovation Team



**Mohammad Hosseini**  
1259431

|                             |                                 |
|-----------------------------|---------------------------------|
| <b>Chairman:</b>            | <b>Prof. Dr. Ir. Nico Baken</b> |
| <b>Supervisor KPN:</b>      | <b>Ir. Pieter Veenstra</b>      |
| <b>Supervisor TU Delft:</b> | <b>Ing. Edgar van Boven</b>     |
| <b>Committee Member:</b>    | <b>Dr. Ir. Marjan Popov</b>     |

October 2010  
Final Version



*“Do not lose your war from without, return to yourself, it is in the inner man that truth dwells”*

(St Augustine)

Copyright ©2009 by M. Hosseini, E.F.M. van Boven, P.K. Veenstra, N.H.G. Baken

All rights reserved. No part of the material protected by this copyright may be reproduced or utilised in any form or by any means, electronic or mechanical, including photocopying, recording or by any information storage and retrieval system, without the permission from the author and Delft University of Technology.

## Abstract

This thesis investigates the past, present and future of energy, telecom and household related developments aiming to pinpoint synergetic innovation possibilities. Providing overview and insights at the aggregation level above, being the sector network, is the first necessary step to reach this goal. The academic part of this thesis focuses on the sector network. Statistics Netherlands provided two data sets: the Working People and Monetary transactions. These data sets reflect a part of the monetary sector network evolution over the last two decades. In this research, we analysed these data sets from a complex network perspective and visualised as a real world network. Next, the data sets were related to the list of vital sectors of the Dutch Ministry of Interior Affairs to observe and understand trends and dependencies among these sectors. This research shows that the Household is the prime and most highly connected node within the sector network closely flanked by Telecom and Energy. The practical part of the thesis focuses on the vital sectors, their infrastructures, the major trends and the added value resulting from their collaboration. A trend analysis of the ICT developments related to the household in 2000, 2010 and expectations of 2020 are examined by means of expert interviews. Combining innovation options related to Energy, Telecom, Healthcare and Household reveal viable, sustainable near future trans-sector solutions. The importance of the information communication value added to Smart Grids is clearly demonstrated. Finally, the development of devices within the home is studied to find out which sectors already have traces in home and which effects would be expected for the telecom sector.

**Keywords:** Smart Living, Holon, Sector Network, Vital Sectors, Vital Infrastructures, Energy, Telecom, Healthcare, Household, Complex Network, Trans-sector Innovation, Smart Home

## Acknowledgement

This Thesis is based on the assignment given to me by the KPN W&O STO Technology & Innovation department.

First of all, I would like to especially thank my daily supervisors Edgar van Boven and Pieter Veenstra. Both supervisors have literally guided me through the process by numerous discussions, organizational support, key questions, valuable comments and reviews they gave on my writings.

Secondly, my special thanks go to Professor Nico Baken, who has advised and inspired me by explaining fascinating research material.

From TU Delft, I especially thank Dr. Marjan Popov for participating in my graduation committee. Furthermore, my special thanks go to Professor Piet Van Mieghem and Dr. Huijuan Wang for supporting me with their knowledgeable insight.

From Statistics Netherlands, I would like to thank experts, especially, Hans van Hooff, for helping me through the whole research and reviewing my thesis. Furthermore, I would like to thank Taeke Takema, Dr. Leon Willenborg and Edwin de Jonge for participating in our workshops and exchanging valuable information.

From KPN, I would also like to thank Dr. Eric Smeitink and Edwin Jongejans for providing me the opportunity to fulfil this graduation internship at KPN W&O STO Technology & Innovation. Additionally, I specially thank Franklin Selgert, Peter Maarten Westerhout, Dr. Ramin Hekmat, Colin Pons, Sander Tolsma, Ad Bresser to contributing in my graduation project by their expertise. Furthermore, I have enjoyed the company of friendly colleagues from W&O STO Technology & Innovation: John Hoffmans, Frans Bak, Lennard Bronkhorst, Rob Reitsma, Ton van der Knaap, Dennis van Maren and Jos Berière.

Last but not least I want to give credits to my friends, family and loved ones who have supported me emotionally by being there for me. In particular, my gratitude goes to my dear parents, sisters and brother, thank you also very much for your love and support. I also thank my student colleague and friends Rasjaad Imamdi and Ruud van de Bovenkamp for reviewing my writings.

The last line I will let for the ones that I did not mention but nevertheless, had a significant contribution to this achievement.

# Table of contents

|   |           |
|---|-----------|
| <i>Abstract</i>   | <b>3</b>  |
| <i>Acknowledgement</i>  | <b>4</b>  |
| <b>1. Introduction</b>  | <b>10</b> |
| 1.1 Motivation  | 10        |
| 1.2 Research Goal   | 11        |
| 1.3 Research questions  | 12        |
| 1.4 Approach  | 13        |
| 1.4.1 Methodology   | 13        |
| 1.4.2 Document outline  | 15        |
| <b>2. Background &amp; domain description</b>                                     | <b>16</b> |
| 2.1 Sector Network  | 16        |
| 2.1.1 Energy  | 17        |
| 2.1.2 Telecom   | 18        |
| 2.1.3 Household   | 18        |
| 2.2 Complex Networks  | 19        |
| 2.3 The Holon theory  | 20        |
| 2.4 Smart Living  | 22        |
| <b>3. Understanding the sector network and its vital sectors</b>                  | <b>24</b> |
| 3.1 Classification systems  | 24        |
| 3.1.1 Overview data from Statistics Netherlands                                   | 25        |
| 3.1.2 Economic classification systems of SBI 1993 and SBI 2008                    | 26        |
| 3.1.3 Working People in The Netherlands   | 28        |
| 3.1.4 Input Output table  | 31        |
| 3.2 Vital Sectors   | 32        |
| 3.2.1 Sector identification by the Dutch Ministry of Interior Affairs             | 32        |
| 3.2.2 Vital Sector Analysis   | 35        |
| 3.2.3 Dependencies of the vital sectors   | 38        |
| 3.3 The Dutch economy as a monetary transaction network                           | 41        |
| 3.3.1 Monetary dependencies of the vital sectors                                  | 41        |
| 3.3.2 Monetary connectedness of the vital sectors                                 | 41        |
| 3.3.3 Ranking of the most dominant sectors  | 46        |
| 3.4 Conclusions from this chapter   | 47        |
| <b>4. A trend analysis of a changing network, its vital sectors and hierarchy</b> | <b>48</b> |
| 4.1 Monetary trends   | 48        |
| 4.1.1 Total household spending in Netherlands                                     | 48        |
| 4.1.2 Production sector network   | 49        |
| 4.2 Monetary analysis of the vital sectors  | 50        |
| 4.2.1 Total monetary transactions of the vital sectors                            | 50        |
| 4.2.2 Monetary transactions between the vital sectors                             | 52        |
| 4.2.3 Trend comparison I/O table and WP for the vital sectors                     | 55        |
| 4.3 Smart Living service bundle   | 57        |
| 4.3.1 Analysing the future needs for Smart Living                                 | 57        |
| 4.3.2 Methodology   | 58        |
| 4.3.3 Results from the expert interviews  | 58        |

|                          |   |            |
|--------------------------|---|------------|
| 4.3.4                    | <i>Impact on the telecom network</i>                            | 60         |
| 4.4                      | <i>Role of ICT in society</i>                                   | 61         |
| 4.4.1                    | <i>Healthcare</i>   | 61         |
| 4.4.2                    | <i>Energy</i>   | 62         |
| 4.4.3                    | <i>Telecom</i>  | 63         |
| 4.5                      | <i>Conclusions from this chapter</i>                            | 66         |
| <b>5.</b>                | <b><i>Data management for Smart Grids</i></b>                   | <b>67</b>  |
| 5.1                      | <i>The current situation and complications of Energy sector</i> | 67         |
| 5.2                      | <i>Smart Grids</i>  | 70         |
| 5.3                      | <i>Decentralised generation and storage</i>                     | 73         |
| 5.3.1                    | <i>Future Microgrids</i>  | 73         |
| 5.3.2                    | <i>Decentralised energy storage</i>                             | 75         |
| 5.4                      | <i>Computational and Telecom capabilities for Smart Grids</i>   | 77         |
| 5.4.1                    | <i>Monitoring and management of the electricity network</i>     | 77         |
| 5.4.2                    | <i>Storage management of electricity</i>                        | 77         |
| 5.4.3                    | <i>Cloud computing</i>  | 78         |
| 5.4.4                    | <i>Smart Metering</i>   | 78         |
| 5.4.5                    | <i>Required telecom capabilities for Smart Grids</i>            | 78         |
| 5.5                      | <i>Conclusions from this chapter</i>                            | 80         |
| <b>6.</b>                | <b><i>Developments of devices for Smart Home</i></b>            | <b>81</b>  |
| 6.1                      | <i>The home as a holon in the sector network</i>                | 81         |
| 6.2                      | <i>Smart Home concept</i>                                       | 82         |
| 6.3                      | <i>In-home device groups</i>                                    | 84         |
| 6.3.1                    | <i>Energy Management</i>  | 85         |
| 6.3.2                    | <i>Security and Access Control</i>                              | 85         |
| 6.3.3                    | <i>Healthcare and Assistive Computing</i>                       | 86         |
| 6.3.4                    | <i>Entertainment</i>  | 87         |
| 6.3.5                    | <i>Home Automation</i>  | 88         |
| 6.4                      | <i>Home network</i>   | 89         |
| 6.5                      | <i>Trends in bandwidth growth and internet connectivity</i>     | 93         |
| 6.6                      | <i>Conclusions from this chapter</i>                            | 95         |
| <b>7.</b>                | <b><i>Conclusions</i></b>                                       | <b>96</b>  |
| <b>8.</b>                | <b><i>References</i></b>  | <b>98</b>  |
| <b><i>Appendices</i></b> |   | <b>101</b> |
| A                        | <i>Inventory</i>  | 101        |
| B                        | <i>Classification systems and their relations</i>               | 104        |
| C                        | <i>Trend analysis</i>   | 112        |
| D                        | <i>Energy sector</i>  | 119        |
| E                        | <i>Home related connections and standards</i>                   | 123        |
| F                        | <i>Definitions</i>  | 128        |
| G                        | <i>Acronyms</i>   | 131        |
| H                        | <i>Matlab code</i>  | 134        |

## Table of tables

|  |     |
|--|-----|
| <i>Table 1: Research questions answers</i>   | 12  |
| <i>Table 2: Number of nodes per classification system level</i>                                    | 25  |
| <i>Table 3: Vital sectors, products/services</i>   | 32  |
| <i>Table 4: vital sectors using Ministry of Interior Affairs definitions</i>                       | 39  |
| <i>Table 5: Energy sector overview</i>   | 69  |
| <i>Table 6: Overview Standardisation initiatives</i>   | 91  |
| <i>Table 7: Inventory of related projects</i>  | 101 |
| <i>Table 8: Mapping sections (SBI 1993), sectors and Input Output table</i>                        | 105 |
| <i>Table 9: Ranking of connectivity vital activity clusters links <math>\geq 1</math> mln</i>      | 108 |
| <i>Table 10: Ranking of connectivity vital activity clusters links <math>\geq 10</math> mln</i>    | 108 |
| <i>Table 11: Ranking of connectivity vital activity clusters links <math>\geq 100</math> mln</i>   | 108 |
| <i>Table 12: Ranking of connectivity vital activity clusters links <math>\geq 1000</math> mln</i>  | 109 |
| <i>Table 13: Ranking of connectivity vital activity clusters links <math>\geq 10000</math> mln</i> | 109 |
| <i>Table 14: Trend analysis 2000, 2010 and expert expectations 2020</i>                            | 117 |

## Table of figures

|   |    |
|---|----|
| <i>Figure 1: Methodology</i>  | 13 |
| <i>Figure 2: Sector Classification derived from ISIC sections and divisions</i>                 | 16 |
| <i>Figure 3: A framework to analyse a multi-weighted network</i>                                | 19 |
| <i>Figure 4: The Holon Model and its layers</i>   | 20 |
| <i>Figure 5: Smart Living matrix</i>  | 22 |
| <i>Figure 6: Visualisation SBI 1993</i>   | 26 |
| <i>Figure 7: Visualisation SBI 2008</i>   | 27 |
| <i>Figure 8: Working People in The Netherlands in 2007 based on SBI 1993</i>                    | 28 |
| <i>Figure 9: Number of working people in section D “Manufacturing” of SBI 1993</i>              | 29 |
| <i>Figure 10: Number of working people in section K “Business services” of SBI 1993</i>         | 29 |
| <i>Figure 11: Number of working people in each section of SBI 1993</i>                          | 30 |
| <i>Figure 12: Vital sectors plotted on the SBI 2008 classification</i>                          | 36 |
| <i>Figure 13: The home in the sector network</i>  | 37 |
| <i>Figure 14: Hierarchic graph of the vital sectors</i>   | 40 |
| <i>Figure 15: Hierarchic graph of the vital sectors (bidirectional graph)</i>                   | 41 |
| <i>Figure 16: Money transaction network 2007 (link weight <math>\geq 1</math> mln)</i>          | 42 |
| <i>Figure 17: Money transaction network 2007 (link weight <math>\geq 10</math> mln)</i>         | 42 |
| <i>Figure 18: Money transaction network 2007 (link weight <math>\geq 100</math> mln)</i>        | 43 |
| <i>Figure 19: Money transaction network 2007 (link weight <math>\geq 1000</math> mln)</i>       | 43 |
| <i>Figure 20: Money transaction network 2007 (link weight <math>\geq 10000</math> mln)</i>      | 44 |
| <i>Figure 21: Degree of link weight <math>\geq 1</math> mln</i>                                 | 45 |
| <i>Figure 22: Degree of links <math>\geq 10</math> mln</i>                                      | 44 |
| <i>Figure 23: Degree of link weight <math>\geq 100</math> mln</i>                               | 46 |
| <i>Figure 24: Degree of link weight <math>\geq 1000</math> mln</i>                              | 45 |
| <i>Figure 25: I/O Network link weight <math>\geq 10000</math> mln</i>                           | 45 |
| <i>Figure 26: Household, Energy and Telecom highly connected activity clusters</i>              | 46 |
| <i>Figure 27: I/O Network 2007 without Household, Energy and Telecom</i>                        | 46 |
| <i>Figure 28: Total household spending in absolute terms and in normalised form</i>             | 49 |
| <i>Figure 29: Total production in absolute terms and in normalised form</i>                     | 49 |
| <i>Figure 30: Monetary dependencies of vital sectors (1993-2007)</i>                            | 50 |
| <i>Figure 31: Incoming euro flows</i>   | 50 |
| <i>Figure 32: Internal euro flows</i>   | 51 |
| <i>Figure 33: Outgoing euro flows</i>   | 51 |
| <i>Figure 34: Outgoing euro flows from the Energy to other vital sectors</i>                    | 52 |
| <i>Figure 35: Outgoing euro flows from the Telecom to other vital sectors</i>                   | 52 |
| <i>Figure 36: Outgoing euro flows from the Finance to other vital sectors</i>                   | 53 |
| <i>Figure 37: Outgoing euro flows from the Healthcare to other vital sectors</i>                | 53 |
| <i>Figure 38: Outgoing euro flows from the Government to other vital sectors</i>                | 54 |
| <i>Figure 39: Household spending's to other vital sectors</i>                                   | 54 |
| <i>Figure 40: Sum of all diagonal elements of the I/O table (1993-2005)</i>                     | 55 |
| <i>Figure 41: Working People (1993-2005)</i>  | 55 |
| <i>Figure 42: Gradient comparison of WP &amp; I/O (diagonal elements)</i>                       | 56 |
| <i>Figure 43: Ratio vital sectors divided by total sector network euro flows</i>                | 56 |
| <i>Figure 44: Total household spending (1987, 2000 and 2007)</i>                                | 63 |
| <i>Figure 45: Total production and spending (1987, 2000 and 2007)</i>                           | 63 |
| <i>Figure 46: Example of one week pattern of Dutch electricity consumption (estimated 2012)</i> | 68 |
| <i>Figure 47: Smart Grid domains</i>  | 70 |
| <i>Figure 48: Smart Grid customer domain</i>  | 72 |



|  |     |
|--|-----|
| <i>Figure 49: PowerMatcher - Basic Structure and Agent Roles</i>                                 | 75  |
| <i>Figure 50: Smart Home electricity production and storage example</i>                          | 76  |
| <i>Figure 51: The home in the sector network</i>   | 81  |
| <i>Figure 52: Smart Home view</i>  | 83  |
| <i>Figure 53: Grouping of in-house devices</i>   | 84  |
| <i>Figure 54: Overview of the network domains connecting the home</i>                            | 89  |
| <i>Figure 55: Possible direction of convergence</i>  | 92  |
| <i>Figure 56: Digital equipment in households (1987-2009)</i>                                    | 93  |
| <i>Figure 57: Trends of communication carriers</i>   | 94  |
| <i>Figure 58: SBI distraction</i>  | 104 |
| <i>Figure 59: Top 4 highest degree activity clusters (Link weight <math>\geq 100</math> mln)</i> | 110 |
| <i>Figure 60: Money transaction network 2007 (Link weight = 0 mln)</i>                           | 110 |
| <i>Figure 61: The SBI 2008 structure of Healthcare (section Q)</i>                               | 111 |
| <i>Figure 62: The SBI 2008 structure of Energy (section D)</i>                                   | 111 |
| <i>Figure 63: Vital sectors, products and services</i>   | 112 |
| <i>Figure 64: Hierarchic graph of the vital sectors (unidirectional graph)</i>                   | 112 |
| <i>Figure 65: Electricity production in Netherland</i>   | 119 |
| <i>Figure 66: Representation of the compressed-air energy storage concept</i>                    | 122 |
| <i>Figure 67: The basic idea of a Femto cell</i>   | 125 |

---

# 1. Introduction

---

## 1.1 Motivation

This research focuses on Smart Living/Home. Inhabitants strive for having a good life and many need to work for a living. A current problem is increasing in-home complexity as the society gradually becomes more complicated, and the inhabitants need to solve all issues from their role of an in-home system integrator. Currently, solitary infrastructures enter the home (such as telecom, energy, water and transport) and many dedicated solutions to improve each of them individually are at hand. In addition, there is an enormous increase in the number of the internet enabled wireless devices and related applications used at work, while traveling and at home. The challenge is to introduce an orchestrated approach in order to realise trans-sector synergy and benefits. This thesis contributes to this current optimization problem by investigating this cross-road of sectors around the home from a trans-sector perspective. It is foreseen that these “Smart Living” developments will further evolve to facilitate solutions for prosperity, well-being and sustainability. This will have a major impact on the infrastructure at home and how intelligent devices will communicate with applications in the direct neighbourhood, city, region, country and world. The household is a vital centre of activities, and it is getting more and more sophisticated over time and increasingly connected to the sector network. For this reason, lots of innovations can be expected in and around the house. Our home environment has its own network, and it is connected to different infrastructures enabled by various devices. Therefore, a trans-sector innovation approach is required because the household connects to the majority of all sectors.

Energy efficiency and sustainability reached the top of the policy makers’ agenda in many countries. With the EU’s goal of 20% sustainable energy by 2020, and the UK government’s plan to roll out smart meters to all domestic customers by the same time, the way has been paved for Smart Grids. Global energy consumption is set to triple by 2050, and power networks need to transform into intelligent systems that will save energy, accommodate increasing amounts of sustainable energy, and ensure supply security. Obviously, telecom companies have a clear opportunity to enable communication facilities for these new needs. Furthermore, the healthcare industry uses telecom facilities to function more efficiently combined with an aging population’s need to use remote monitoring to promote better care. Patients can be treated in their own homes. Thereby proving an irresistible lure for telecom service providers, that now are starting to consider telehealth and telemedicine as new business opportunities.

On the journey to search for new business for KPN, we look at various important trans-sector combinations. We think that many economic connections exist, which enable transactions, between sectors where a lot of money flows and where many people are involved. Therefore, a monetary analysis on money transactions is relevant to understand the sector network from the economic perspective. Furthermore, to describe a Smart Living service bundle, an inventory of in-home devices and standard developments are crucial to study.

## 1.2 Research Goal

The research goal of this thesis unfolds into an applied and academic part.

### **Applied part of this thesis (KPN)**

Due to the further decreasing revenue from traditional telecom services (where voice is becoming just another service) operators like KPN are forced to look for new business initiatives. In the past years services like Mobile, the Internet, Voice-over-IP and lastly TV were introduced within more or less the same technology and business context. These services are offered in strong competition with other telecom operators and moreover, in competition with cable operators and the Internet facilitated service offerings by parties like Skype, Google, Facebook, etc. In addition, operators like KPN need to invest heavily in new infrastructure like Fibre-to-the-Home (FtH) and capacity upgrades of the mobile network. As a result, the traditional telecom operators are forced to look for new business initiatives. These new business initiatives refer to partnerships with energy companies, healthcare institutes and others to become actively involved in services around the house and the daily life. Therefore, KPN is taking part in the TRANS consortium including the Smart Living program. The main aim of the applied part of this thesis is to explore and identify novel trans-sector service combinations. In addition, this thesis pays special attention to the developments of Smart Grids and Smart Home.

### **Academic part of this thesis (TU Delft)**

The Trans-sector Innovation team, part of the Network Architectures & Services (NAS) group of the Electrical Engineering, Mathematics and Computer Science Faculty, Delft University of Technology, is currently researching two data sets provided by Statistics Netherlands. The first data set aggregates all monetary transactions observed over the period 1987 - 2007 in The Netherlands among 105 different activity clusters. The second data set to study at a more in-depth level is the detailed data set of working people per activity group. Accordingly, this valuable information can help us to understand the value of the trans-sector innovation with the Telecom sector as the connecting hub in the sector network (integrating role). Within this thesis, we investigate the impact of a future Smart Living service bundle for KPN. To be able to predict near future needs of telecom, we aim to establish an understanding of the main trends of the recent past. Thereby we want to identify the vital parts in the sector network, in order to determine whether the Telecom sector can add substantial value. A preliminary study has shown that for the Telecom sector the Household, Energy and Healthcare sector seemed very promising to generate new value, especially by combined innovation. For this research project, the concept of Smart Living is about integrating the home environment to the eco-system which increases the total energy efficiency, serves the healthcare institutions and sees the household as the central point where the majority of all services are delivered. The scope of this MSc project reduces itself to networking aspects of Smart Home, which operate as interface of the Households with the Energy, Healthcare and Telecom sector.

## 1.3 Research questions

### Understanding the sector network and its vital sectors

1. How are the activity clusters within the Dutch sector network classified?
2. Which sectors can be qualified as vital sectors and how strong are their economic relations and dependencies?
3. How are Working People distributed over the Dutch sector network?
4. What is the meaning of a node weight in de context of the sector network?

### A trend analysis of a changing sector network, its vital sectors and hierarchy

5. How did the vital sectors evolve within the sector network (looking at connectedness and monetary transactions)?
6. What are the main trends and expected developments that involve the Household, Telecom and other vital sectors (2000, 2010, expectation 2020)?
7. Which of these developments comprise Telecom/IT solutions and which examples can be envisaged?

### Data management for Smart Grids

8. What are the (main) current issues and developments concerning the energy sector?
9. What are Smart Grids and what are the innovation possibilities with Telecom?
10. Which information flows can/may exist in support of Smart Grids?

### Development devices for Smart Home

11. What are the developments of hardware, middle-ware and software in Smart Home/Living related devices and how far are these developments standardized?
12. What do these developments require from the telecom network?

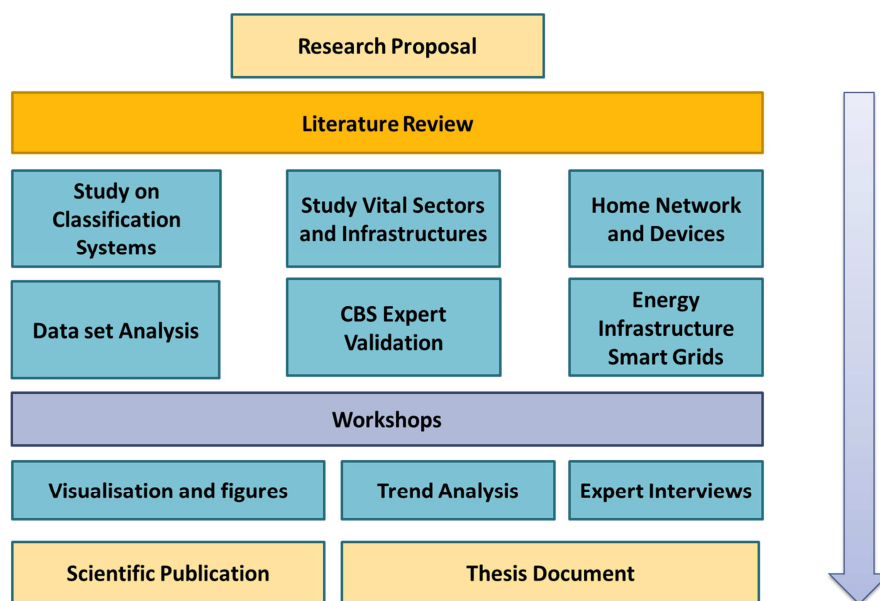
**Table 1: Research questions answers**

| Research Questions | Answered in chapter / paragraph / subparagraph / appendix |
|--------------------|---|
| <b>1</b>           | 3.1   |
| <b>2</b>           | 3.2   |
| <b>3</b>           | 3.1.3   |
| <b>4</b>           | 2.2, 4.2.3  |
| <b>5</b>           | 3.3   |
| <b>6</b>           | 4.3, C.3  |
| <b>7</b>           | 4.3.3, 4.4 , C.3  |
| <b>8</b>           | 5.1   |
| <b>9</b>           | 5.2   |
| <b>10</b>          | 5.4   |
| <b>11</b>          | 6.3, 6.4, E   |
| <b>12</b>          | 6.6   |

## 1.4 Approach

### 1.4.1 Methodology

To find answers to the research questions, a detailed approach was described in a separate document (Research Proposal). This subparagraph describes the planning of each research part as illustrated in Figure 1. Initially, literature review is performed for each research part. In the context of Smart Living, trans-sector innovation is closely related to households, and therefore it requires study on household related sectors. At least Energy, Healthcare, and Telecom are involved because households and their inhabitants strongly depend on their delivered services. In the academic part of this thesis, all sectors are involved, with the emphasis on vital sectors.



**Figure 1: Methodology**

#### Home devices and Smart Grids

Furthermore, in-depth literature review is carried out based on the research questions and refined scope of the research. First several papers and documents were reviewed about the different subjects, namely home devices, energy infrastructure (Smart Grids). In these two parts developments of in-home devices and their standardisation are investigated and discussed with experts of industry.

#### Study on classification systems

In this thesis, the classification systems SBI 1993 and SBI 2008 based on the International Standard Industrial Classification of All Economic Activities (ISIC) were studied. Two plots were made to visualize the structures of SBI 1993 and SBI 2008. Then the 2007 data set of Working People (WP) is plotted over the classification of SBI 1993. After receiving the data set of WP for 1993-2005, a graph is plotted for each year on the amount of people reflected in the structure of SBI 1993, and an animation followed, which shows the changes of the number of employees over the period 1993-2005.

#### Data set Analysis

Furthermore, a data analysis is carried out on the Input Output (I/O) table, where a monetary transaction network is constructed for each year in different ranges. For the purpose of this analysis, the I/O networks of 1993-2007 are constructed, which is combined in an animation to show the changes in sector connectivity during that period.

### **Study Vital Sectors and infrastructures**

Another input corresponding to this research is the list of Vital Sectors provided by Ministry of Interior Affairs (MinBZK). We use this MinBZK list to identify and relate the vital activity clusters derived from the I/O table activity cluster list. This exercise is useful for merging monetary transactions of different vital sectors in order to calculate how much money is transacted between the vital sectors, and find out their monetary dependencies. Experts of Statistic Netherlands helped us with validation of our approach and reviewing the results.

### **Visualisation and figures**

During this research various graphs, figures and two animations were produced for various research purposes. These visualisations are carefully studied, and the useful observations are derived to support the conclusions. The visualisations that are not included in this thesis (or in the appendices) are delivered in a CD ROM to the NAS group.

### **Workshops**

During the research workshops related to the thesis were organized and attended:

- “Broadband Home: today and tomorrow” of TNO,
- “Smarter Telecom” event of IBM,
- “Cloud Computing” workshop of Cisco.

Furthermore, various workshops and presentations have been provided to other groups, e.g. workshop with Statistic Netherlands (SN) about the I/O network research and separate presentations to TU NAS team and SN.

### **Trend analysis**

Furthermore, a monetary trend analysis of the vital sector was carried out. From the I/O table data set a subset was selected that allowed for deriving the monetary trends concerning the vital sectors during the period 1987-2007. Where necessary non-vital parts belonging to vital sectors were identified and not taken into account in these calculations.

### **Expert interviews**

In addition to the trend analysis, expert interviews were carried out with innovation experts at KPN. From these interviews, we abstract the feasible options they expect to concern the future Smart Living service bundle. This outside-in approach will as well contribute to bring the envisaged Smart Living/Home concept closer to a realization.

### **Scientific Publication**

The academic part of this thesis is closely related to a paper called: “*Characterizing Multi-weighted Networks: The Dutch Economy as a Monetary Transaction Network*”, currently prepared for publication by the NAS research group of Delft University of Technology [1].

## **1.4.2 Document outline**

This subparagraph briefly outlines the structure of this thesis:

### **Chapter 1: Introduction**

This chapter presents the motivation, research goal, research questions, and methodology of this research.

### **Chapter 2: Background & domain description**

This chapter explains the theoretical framework related to this thesis. First the Sector Network is briefly explained including the vital sectors Energy, Healthcare, Telecom and Household. Furthermore, it is explained that the Sector Network is a Complex Network, and to grasp the complexity of these kinds of networks, the Holon theory is very useful. This will help the realisation of the implementations envisaged by the Smart Living program members.

### **Chapter 3: Understanding the sector network and its vital sectors**

In this chapter we look at examples of real life complex networks. One of the examples is the sector network, which shows a hierarchy in the sense of different levels of classifications. Furthermore the observation of the available data is presented. The available data sets of Statistic Netherlands were used to investigate the complex monetary network and the working people in the Netherlands.

### **Chapter 4: A trend analysis of a changing sector network, it's vital sectors and hierarchy**

In this chapter of the research, the trends found from the data are discussed and combined with the information collected from the expert interviews to describe the future possibilities of the Telecom sector involving in other sectors. This is based on the findings in chapter 3 and the trend forecast served to create a vision of the possibilities of the future Smart Living related concepts, the so called future vision.

### **Chapter 5: Data management for Smart Grids**

To explain what Smart Grids are, a literature review was performed to understand what kinds of requirements are addressed to the Smart Grid concept. Next the focus was dedicated to the information flows within this future Grid network. Furthermore the current metering service was studied to predict the future needs of the more advanced Smart Grids.

### **Chapter 6: Developments devices for Smart Home**

To investigate the developments of devices for Smart Home, a literature review was performed of the Smart Home concept. Subsequently, the standards were investigated covering the home network and device connectivity, followed by the trends in bandwidth growth and internet connectivity.

## 2. Background & domain description

### 2.1 Sector Network

On a macroscopic level society and economy can be decomposed into roughly 20 sectors that together provide the foundations for our daily lives. A sector can be defined as a cluster of homogeneous activities. Each sector performs generic functions and a few sector specific functions. The functional decomposition has been possible by means of tasks division between those sectors and specialization in specific skills. On the one hand, enterprises can be characterized by the processes and activities they perform [2]. On the other hand, sectors are an upper aggregation level of enterprises and non-profit organisations. We can cluster activities based on an appropriate and global agreed classification system in order to define sectors [3]. Examples of commonly recognized sectors are Construction, Education, Finance, Healthcare and Transport. Together the sectors are densely interlinked and thus form a sector network [4].

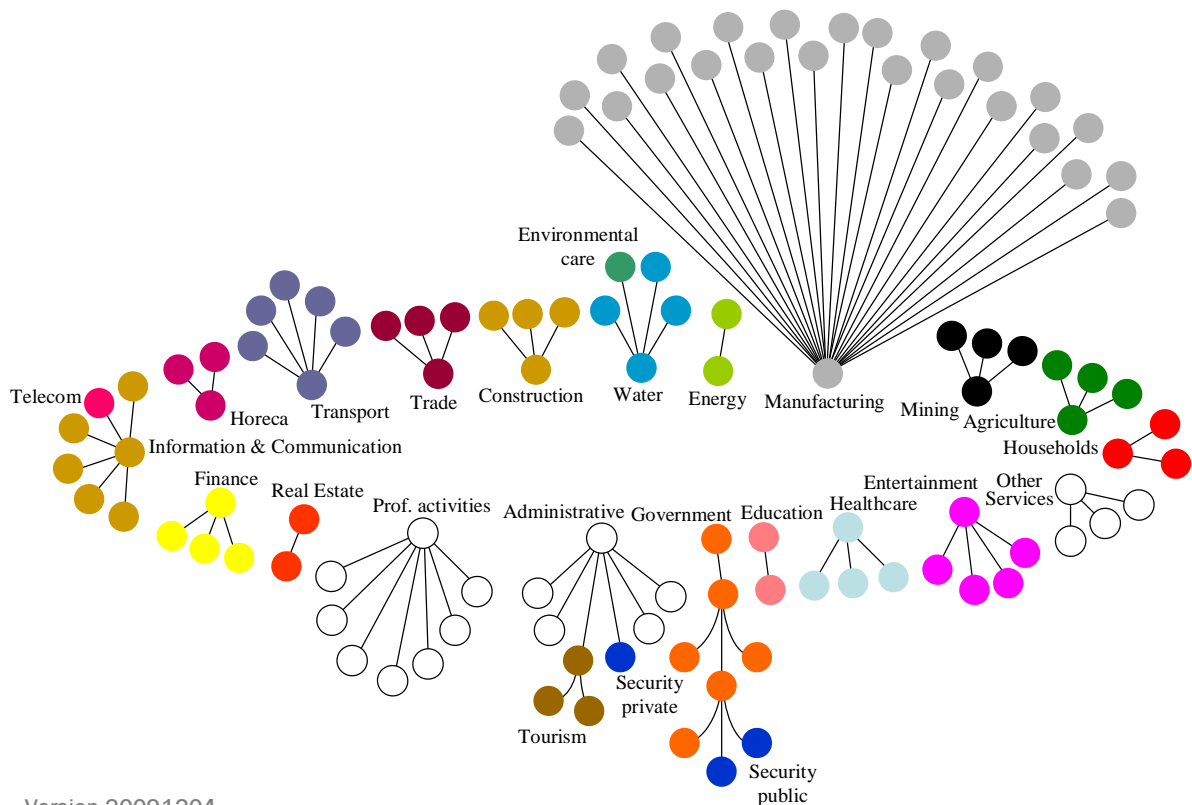


Figure 2: Sector Classification derived from ISIC sections and divisions



Figure 2 shows a simplified image of the sectors based on the activity classification derived from the International Standard Industrial Classification of All Economic Activities (ISIC) [6]. The current Dutch activity classification which is provided by Statistics Netherlands (SN) follows in aggregated level the ISIC classification.

The sector network can be represented as a layered graph. At a superior level, the sectors are the nodes and the information, money, goods and services traverse the links in between them. This Sector Network certainly is a Complex Network<sup>1</sup>. It reflects real time exchanges and existing interactions. It is therefore, very interesting to study the Sector Network from both an academic and an entrepreneurial perspective. Some sectors provide vital value to the sector network than other ones. We speak of vital sectors and their vital infrastructures, when they offer products and services that require a very high availability and reliability. If they fail, social disruption at the national scale is the case, especially when restoring takes a long time and economic losses are high [5].

Within this thesis, the main focus will be on the vital sectors Energy, Telecom and Household, and the different infrastructures that connect the household. As well, some high level effort was spent on studying the Healthcare sector relations.

### **2.1.1 Energy**

Currently, our energy problems can no longer be solved when maintaining the status quo of the energy system as a whole. Therefore, technological breakthroughs are needed and the user needs to change its energy consumption habits. Furthermore, the infrastructure must be adapted to achieve the transition to a sustainable energy system. The importance of this energy transition is mainly conscious by businesses and households more than ever. Rising energy prices provide an additional incentive to energy savings and to invest in sustainable energy alternatives. This momentum shall be used to set the right steps towards an energy system where future generations can continue.

Most of the world's power system was built over the last 40 to 60 years. In order to increase the reliability of the power system, smart online monitoring of electrical quantities should be implemented. The electric power system still relies heavily on the fossil energy sources. During high demand periods when the capacity is tight, utility companies rely on flexible gas and oil power stations, which is expensive and polluting. The urgent need to move towards low carbon economy, unpredictable fuel costs, aging infrastructure and climate change are all converging to require a radical transformation of electric systems and the utilities industry.

According to the "Energierapport" [56], the Dutch energy supply system has to be regulated in a fundamentally different way. The system must become smarter, cleaner and more varied to meet the rising energy demand. This is necessary for CO<sub>2</sub> emissions reduction and climate change. Moreover, it is also because the Energy sector does not want to be dependent on few energy sources and few energy-producing countries. In 2050 the energy supply must be substantially cleaner in Europe (including The Netherlands), smarter and more varied. However, if households and businesses generate much more energy than their current energy supply, 50% less CO<sub>2</sub> emission in 2050 is possible. Recognizing these challenges, the Energy sector is starting to collaborate with the Telecom sector in order to create a Smart Grid as the Telecom sector can be a major contributor in the realisation of a smarter energy infrastructure [57].

---

<sup>1</sup> E.g. the Internet is commonly referred to as a complex network. As the Internet is only one out of many contributions of the sector network, the latter can be considered to be a complex network too.

### 2.1.2 Telecom

Given the fact that there is no global consensus about the definition of a sector and the activities that belong to each one of them, below the Telecom sector is defined from a classification and a functional perspective. Thus, for the purpose of this thesis, we consider the Telecom sector to be an alternative aggregation, containing all the activities corresponding to ISIC division 61, and additionally including the broadcast function mentioned in division 60 in ISIC Rev.4 [6]:

- 60 - Programming and broadcasting activities
  - 601 - Radio broadcasting
  - 602 - Television programming and broadcasting activities
- 61 - Telecommunications
  - 611 - Wired telecommunications activities
  - 612 - Wireless telecommunications activities
  - 613 - Satellite telecommunications activities
  - 619 - Other telecommunications activities

From a functional perspective, the Telecom sector could be defined as the sector serving both economy and society that offer its Value Added Services (VAS) relying on its unique capability of transferring data by means of electro-magnetic (EM) waves [3]. The telecom sector has become the preferred connection point, which is a hub in the sector network, connecting all the sector nodes and the people who work within. Moreover, people in their private role enjoy the use of telecom services in their private environments and communities [4].

### 2.1.3 Household

Traditionally, the household is commonly associated with the main consumer role within the sector network. Moreover, ISIC defines the household as a section. In recent years the household is adding more functionalities to its classical role. In addition, the household is becoming a producer of energy. A household is defined as the activities being taken to a life situation of one or more persons acting jointly in a home, to maintain. Furthermore, the social situation itself is often referred to as a household. The households include both the house and its near surroundings, and the persons living there. The households are divided into a composition (e.g. single households or multi-person households) and the location in the household of a member of it. From the 7.3 million households in the Netherlands, 57% is formed by couples, with or without children at home, and 36% by singles. The remaining 7% consists mainly of single-parent families. In the year 2010 the Netherlands counted an average of 2.22 people per household<sup>2</sup>. In this thesis, we consider the household to comprise:

- the citizens/inhabitants who are registered to live within a resident home
- the physical home and its inventory, e.g.:
  - all devices at the premises
  - the local telecom network
  - the local energy network
  - the transportation means owned by all inhabitants
- the garden/surrounding owned
- the financial resources owned by all inhabitants

---

<sup>2</sup> Source: CBS StatLine - Huishoudens; grootte, samenstelling, positie in het huishouden, 1 januari 2010

## 2.2 Complex Networks

Complex networks are a relatively new field of research, resulted from graph theory, which focuses less on the study of small graphs. So the main focus is not on properties of individual nodes and links in these graphs, but rather on the statistical properties of large scale networks. Following is a quote from Newman’s publication, which explains the novelty of complex network theory:

*“The study of complex networks is still in its infancy. Several general areas stand out as promising for future research. First, while we are beginning to understand some of the patterns and statistical regularities in the structure of realworld networks, our techniques for analyzing networks are at present no more than a grab-bag of miscellaneous and largely unrelated tools. We do not yet, as we do in some other fields, have a systematic program for characterizing network structure. We count triangles on networks or measure degree sequences, but we have no idea if these are the only important quantities to measure (almost certainly they are not) or even if they are the most important. Perhaps there are other measures, so far un-thought-of, that are more important than those we have at present. A true understanding of which properties of networks are the important ones to focus on will almost certainly require us to state first what questions we are interested in answering about a particular network. And knowing how to tie the answers to these questions to structural properties of the network is therefore also an important goal.”* (Newman et al. 2003)[7]

In this thesis, we study an economical network: its monetary transactions (link weights), amount of money circulating inside an activity cluster and number of working people (node weights), and network topology (degree). The concept of node weight is not widely investigated compared to the link weight concept. Our definition for node weights which is going to be published in academic paper “Characterizing Multi-weighted Networks: The Dutch Economy as a Monetary Transaction Network”, states:

*“The weight  $w_i$  of a node  $i$  can be placed on the diagonal of matrix  $W$ . Matrix  $W$  can be defined as a weighted adjacency matrix. In this way, the node weight can be understood as the weight of a self-loop.”*[1]

In this thesis we investigate the node weights, link weights and degree within the sector network.

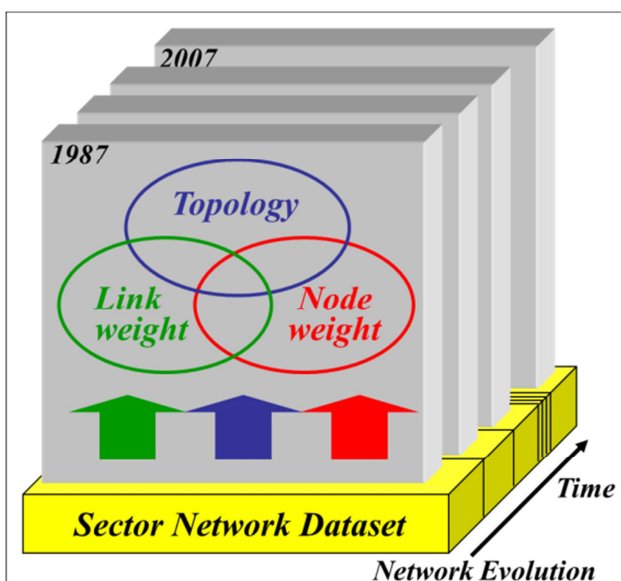


Figure 3: A framework to analyse a multi-weighted network [1]

Figure 3 shows the framework to analyse a multi-weighted network, which explains the broad scope of monetary network evolution [1]. In this framework three interrelated domains are involved:

- Topology: the physical interconnections of the elements within the network.
- Link weight: associates a weight to each link
- Node weight: assigns a weight to each node

The first two domains are mature in complex network theory, but the last is a new research area [50].

## 2.3 The Holon theory

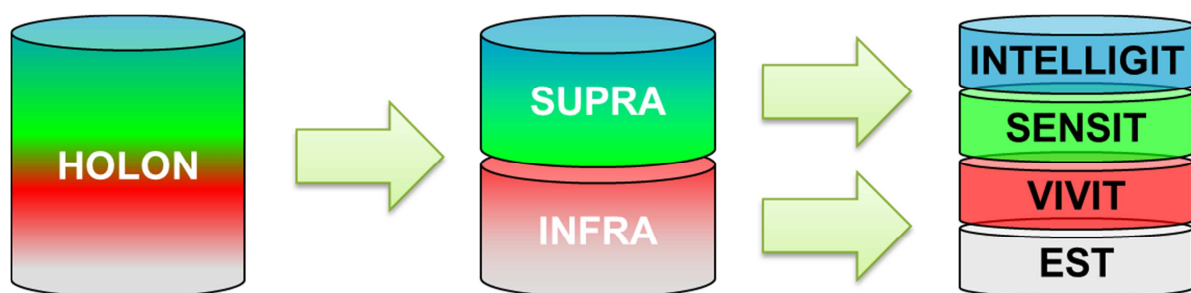
Holons are logical entities that are both a whole and a part. A holon can be either conceptual or real. One can distinguish and perceive a holon from its environment as a logical entity. A real holon can change over time, a conceptual holon cannot. The word holon was coined by Arthur Koestler in 1967 [49], but as he points out, the concept has a long and distinguished history. Koestler introduced the term holarchy too, being a hierarchic network consisting of holons. Also others have mentioned the holon concept in a network context, for example, Lévi-Strauss, a famous and influential French thinker wrote:

*“The individual becomes meaningful as part of the network that transcends it.”<sup>3</sup>*

In this statement, an individual is not only related to the network, but is proclaimed to add value while being able to overview and understand its surroundings. According to Professor Nico Baken:

*“A holon becomes meaningful as part of the network that transcends it.”<sup>4</sup>*

In this way, the individual is related to the network in a holonic context. Note that groups of individuals can be a holon too. Concerning the natural evolution of the human brain four layers were mentioned by P. Vroon [8]. Being an adaptation process, evolution proceeded in the following order: est-vivit-sensit-intelligit. We can see how the functional decomposition is a “natural tool” to cope with complexity in order to deal with new contextual conditions.



**Figure 4: The Holon Model and its layers**

In Figure 4 we see the holon model and its layers. As proposed by Professor Nico Baken, a holon consists of a SUPRA and INFRA part. SUPRA is Latin for “above”, INFRA stands for the palpable/tangible

<sup>3</sup> Source: NRC 4 November 2009 “Claude Lévi-Strauss (1908-2009) Scherpzinning denker over beschavingen”

<sup>4</sup> See also TEDx presentation of Prof.dr.ir. Nico Baken: <http://www.youtube.com/watch?v=EDZtJaefpZE>

infrastructure part of a real holon. Subsequently, these two parts can be subdivided into four hierarchic layers:

1. Intelligit: Relates to offering and providing solutions
2. Sensit: Relates to processes
3. Vivit: Relates to active infrastructure
4. Est: Relates to passive infrastructure

Thus the Intelligit and Sensit layer together belong to the non-palpable SUPRA part and the Vivit and Est layer belong to the INFRA part. By means of these four layers nearly every relation and property of a holon can be explained. A real holon can both be a primary and a secondary actor, being a part of a supply and demand eco-system.

From hundreds of possible different functions (that can be described by means of verbs) three meta-functions capture all thinkable functions a holon can perform: *Transform*, *Transfer* and *Transact* [55]. In a transformation of value or transformation of products or services (presented in that holon), the nodal value of that holon will change. If there is a sufficient value, the node will be saturated in specified time, and a particular node value, product or service will be transferred to another node, which corresponds to the transfer of value. And therefore, a transaction is needed. The node can also be seen as a holon, which gets saturated and at one point the value of this node flows to another entity equivalent to this holon. The holons can change dynamically because inside them happens transformation of value, and they might transmit value to other neighbour holons.

If we approach a household from a geographic living area perspective, a country can be considered as a holon connecting to adjacent countries. Inside a country there are other holons, provinces and cities. And inside cities there are different neighbourhoods as holons. Finally, inside each neighbourhood there are individual houses, which are again holons.<sup>5</sup>

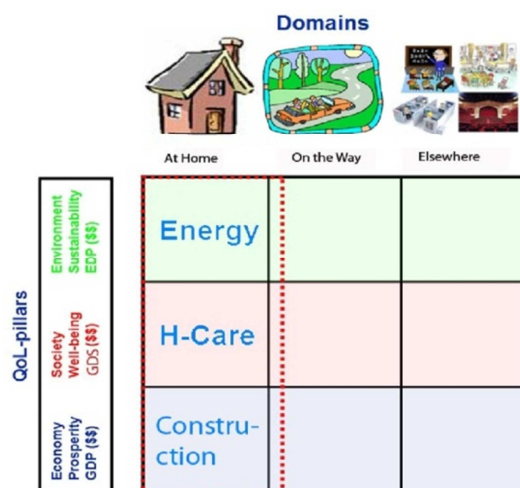
---

<sup>5</sup> See: Lecture of Paul van Pelt “Smart Living Het Huis, de Buurt en de Bouw”

## 2.4 Smart Living

Smart Living is an intuitive term, chosen as a name for both an innovation program and a concept. French philosopher Pierre Hadot, in particular, showed that in the Greco-Roman antiquity philosophy was a form of life, life art, based on daily spiritual exercises to shape for the spiritual welfare of yourself and others. It is an exercise with your entire psyche, your spirit, involving a polite relationship with the transcendent in the present. In other words, philosophy and psychotherapy in ancient times were both about a good life. Working on yourself was seen as something that was important [63].

The Smart Living program aims to contribute to improve the Quality of Life of society, balancing the limited resources. As a concept, Smart Living invokes ideas of homes equipped with energy efficient automation systems, residential identification mechanisms, automated security systems, integrated media management and content sharing facilities, integrated communication systems, remote healthcare amenities, offices allowing remote working, etc. Smart Living aims to improve the social well-being of the individuals in a sustainable environment in a friendly way.



**Figure 5: Smart Living matrix**

According to Professor Nico Baken, we can roughly distinguish three areas in which we as humans can move. Either we are at home (in the neighbourhood), elsewhere (e.g. at work, at school) or travelling. Our perspective of Smart Living, suggests that the home domain is the central area where we appear most often. On this basis, we describe how we can use ICT means to restore the balance in our fragmented society, bringing pieces of the puzzle together. The selection of this home domain is not arbitrary: to this domain the majority of all sectors connect and a lot of social trends and problems are applicable (think of aging or social cohesion). Within this domain we can use a more comprehensive and holistic approach to gain substantial benefit and value, and thus a significant improve the quality of our lives. This approach captured by four P's unfolds into [53]:

- **People** (social aspects): employment opportunities, employment policies, control, safety and health, etc. Also human rights is part of this P (including employee rights and policy regarding child labour, forced labour and non-discrimination policy towards corruption).
- **Planet** (environmental aspects): the attitude of the company towards the environment, the impact of environmental risks and liabilities on the financial position of the company.
- **Profit** (economic aspects): taxes, distribution of added value among the stakeholders, the social creation and dissemination of knowledge through research and development, training, etc.

- **Pneuma<sup>6</sup>** (spiritual aspects): sustainability can really take shape only if it is inspired by an individual and collective consciousness of human evolution with regard to the connectedness of all existing.

We call this Smart Living. To concretise our understanding of Smart Living, we first outline an image of a Smart Living neighbourhood, with concepts like “together, decentralized, sustainable and trans-sector” [9]. As people are either at home, on their way, or in a venue somewhere else, seamless data storage and bridging geographic distance for any communication purpose is expected to be a common requirement. Enhancing the role and position of Telecom in the life of the future Prosumer, would be the transactions network, which allows the Prosumer to remotely conduct and control all the transaction involved in his life across all sectors. Therefore, the future Smart Home and its inhabitants will use functionality enabled by the telecom sector via Smart Living.

In this future scenario, we observe networks at two aggregation levels. The first one is the Sector Network which constitutes all social and economic activity and the second one is the Telecom Network within the Sector Network, which enables communication and interaction. As explained above, one of the properties of a holon is, when zooming into a holon there will be found another network inside of it. A holon can be approached in different ways, and what can be observed depends on the specific relation type of these two holons, either in the same hierarchical level or not. From both the sectors Telecom and Energy, the household consumes their services. From a specific service perspective, the household is buying electricity or gas from the Energy sector. From the Telecom sector, they enjoy fixed and mobile connections enabling various value added services e.g. telephony, TV and Internet access. In the Netherlands 7.3 million people work on a total population of 16.4 million. In each household live 2.22 people on average. From this perspective 44% of all citizens earn money in return for their work for organisations in any sector.

The Smart Living program deals with houses and neighbourhoods, while helping to organize our lives based on the mentioned four P’s. Combining innovation options related to Energy, Telecom and Household reveal viable, sustainable near future trans-sector solutions. Trans-sector Innovation requires communication between many different actors and roles in the value web. Information and communication technologies can play an important role in automating and controlling these often complex information flows. Two conditions play a role for ICT infrastructure suitable for this purpose: make uniform network and IT architectures and use open interfaces [10]. Innovations in Information and Communication Technology such as greater and ubiquitous broadband access, increased Quality of Service (QoS) and home gateways provide great opportunities to realise communication and service delivery infrastructures, which can be shared across sectors. ICT innovations allow services in other domains such as Energy and Healthcare to be deployed in a timely and cost-effective fashion [11]. Within the Telecom sector, the current stovepipes are gradually lacing up to a Multi-service Platform. The reasons for this transformation from dedicated solutions to a layered platform are:

1. Cost reduction.
2. Flexibility of entering new services.
3. To make packages of services and sometimes trans-sector packages to help the customer in a resolution manner.
4. Technological tilt, which has its organizational consequences for each part of the business range.

---

<sup>6</sup> Sometimes, a “fourth P” is added to the People, Planet and Profit, which represents the humanity (“zingeving”). This “fourth P” derived from the ancient word “Pneuma” (spirit, inspiration), “Persona” or “Psyche”. The first person who used the “fourth P” used was Mgr. A.H. van Luyn in a lecture in 2001 [54].

# 3.

## Understanding the sector network and its vital sectors

---

*In this chapter, we investigate the Dutch economic activity classification structure and the data sets Working People (WP) and Input Output table (I/O). First we describe this input provided by SN. Then we introduce the vital sector's list which is provided by the Ministry of Interior Affairs, and identify the vital sectors within the data sets. Furthermore, we investigate the relationships between the vital sectors, in particular, the amount of money flowing between them and number of people working in each of these sectors. Finally, we analyse the monetary flows between the vital sectors related to the Household sector.*

### 3.1 Classification systems

Currently, the most prevalent standard classification system is the International Standard Industrial Classification of All Economic Activities (ISIC) [6] provided by the United Nations to all member states, enabling them to transparently classify their (national) economic activities. Currently, most national statistics departments use (and comply to) the ISIC standard as a general framework to define and structure their national statistical data sets. The most recent ISIC version [6] comprises 21 sections, subdivided into 86 divisions. Users can derive from these sections and divisions a list of sectors, sub-sectors, etc., for their own specific purposes. The sector network, studied in this paper, is based on the Dutch Input Output table (I/O) provided by the National Accounts department of Statistics Netherlands. This table contains a monetary transaction matrix that reflects the yearly produced and delivered value inside and between 104 economic activity clusters thus addressing at least all 85 ISIC divisions. As the role of the household is increasingly important we added consumer spending and salaries to the data set being the 105th node in the sector network [1].



### 3.1.1 Overview data from Statistics Netherlands

**Table 2: Number of nodes per classification system level**

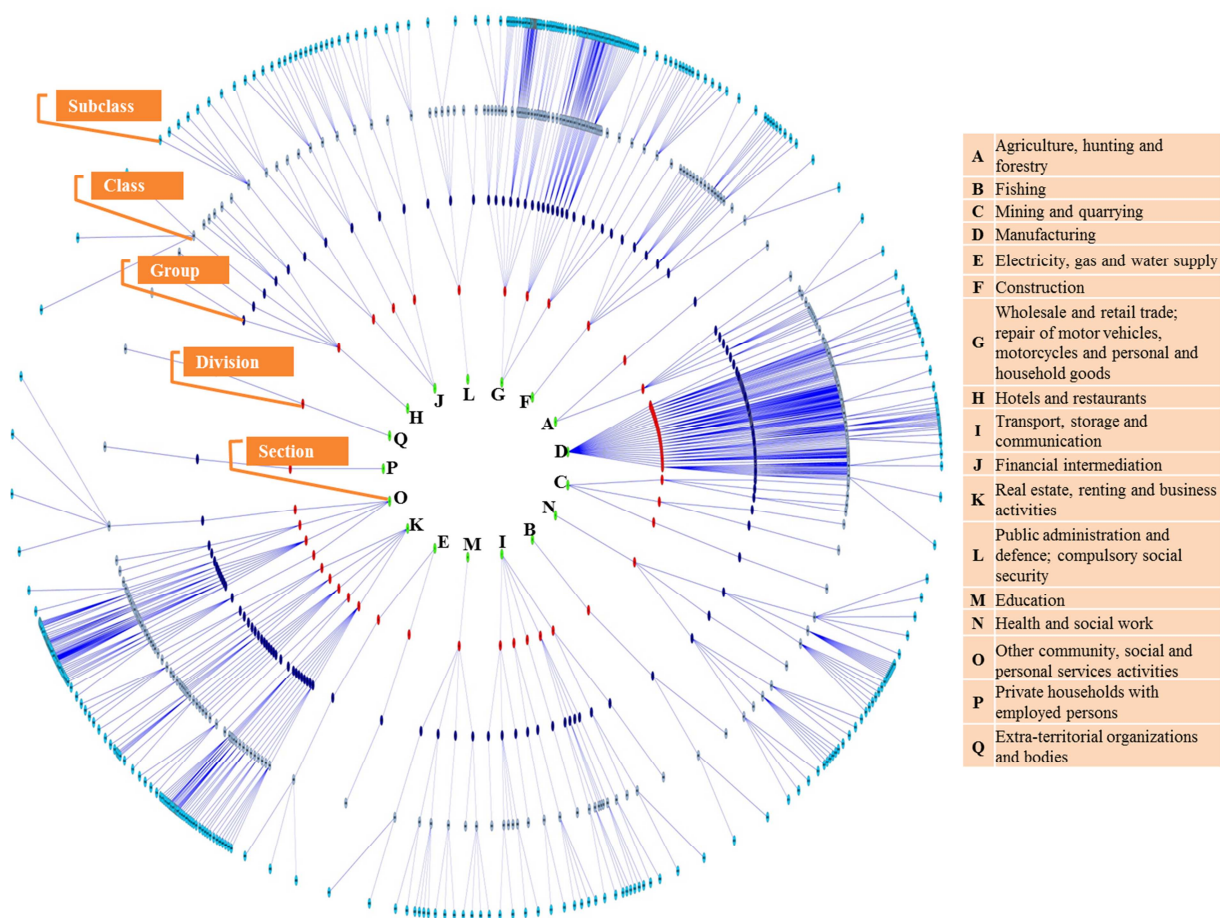
| Level     | SBI 1993   | SBI 2008                                       | WP 1993-2005                             | WP 2007                                  | I/O 1987-2007   |
|-----------|--|--|--|--|---|
| Section   | 17   | 21   | 14                                       | 15                                       | 104   |
| Division  | 58   | 86   | 55                                       | 56                                       |   |
| Group     | 211  | 266  | 167                                      | 174                                      |   |
| Class     | 499  | 428  | 224                                      | 453                                      |   |
| Sub Class | 492  | 603  | 227                                      | 286                                      |   |
| Remarks   | classification, currently valid for all national reported data | classification, no reported data available yet | number of working people, based on SBI93 | number of working people, based on SBI93 | 104 by 104 matrix of produced value in millions of euro, based on SBI93 |

Table 1 above gives an overview of the structure of:

- The “Standaard Bedrijfsindeling” (SBI)
  - SBI 1993 [58]
  - SBI 2008 [59]
- The Working People (WP)
  - WP 1993-2005
  - WP 2007
- The Input Output table (I/O)
  - I/O 1987-2007

SBI 1993 and SBI 2008 are the two most recent Dutch classification standards that were accepted by SN in the year 1993 and 2008 respectively. Furthermore, we have worked with a detailed historical WP data set, where the numbers are available at each classification level: section, division, group, class and subclass. The WP data is available from the years 1993 to 2005 and 2007. At a first glance, we see that the number of nodes in each level of the two historical data sets differ in each data set (it could be the case that the counting process is more accurate in 2007). During our research WP data was not yet available based on the structure of the 2008 standard.

### 3.1.2 Economic classification systems of SBI 1993 and SBI 2008

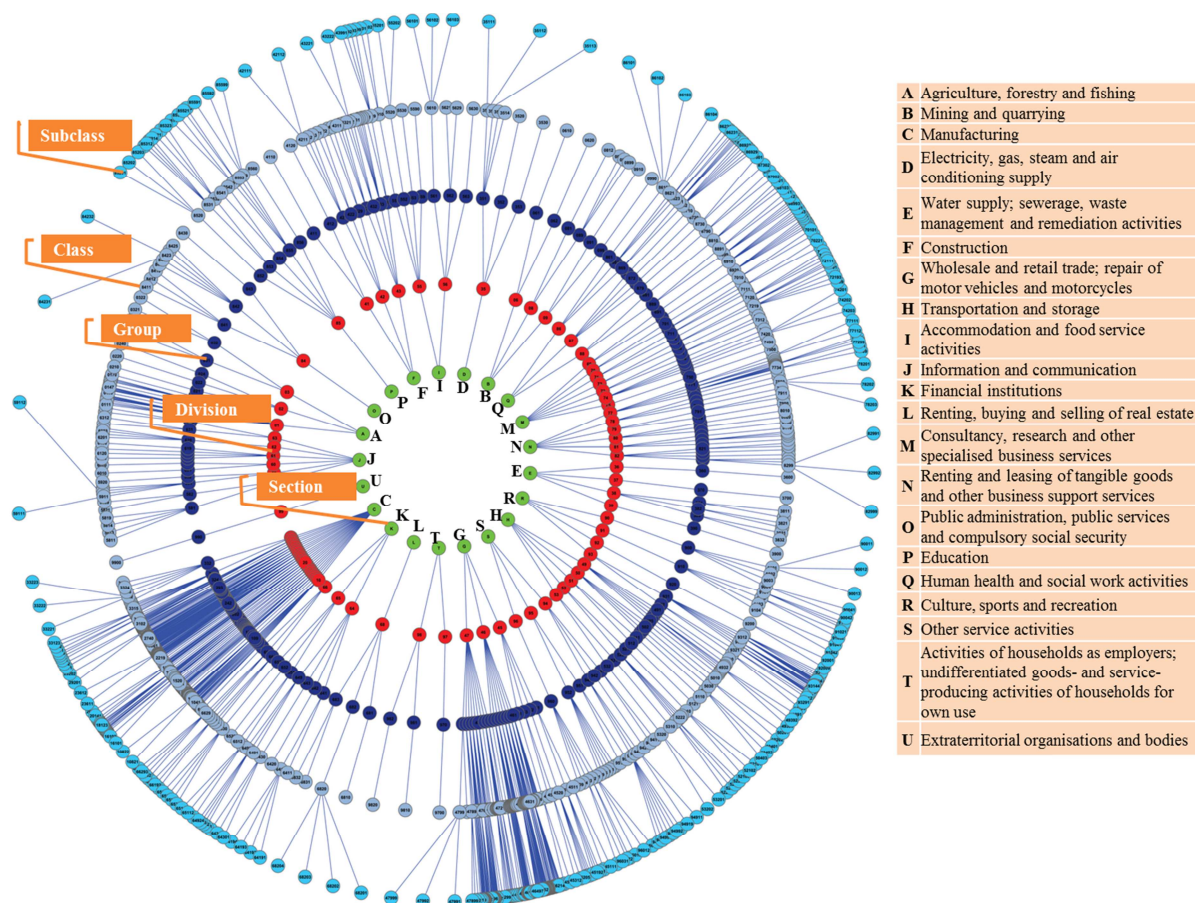


**Figure 6: Visualisation SBI 1993**

Figure 6 illustrates the SBI 1993 classification system plotted by means of the application Cytoscape. SBI 1993 contains 17 planar tree structures, where the section level can be considered to be the root of each tree (A to Q, see Figure 6 on the right hand side). The hierarchical structure unfolds into divisions, groups, classes and subclasses. We observe that the Manufacturing (section D) for example, has a very dense planar tree, strong opposed by section Q “*Extra-territorial organizations and bodies*”, P “*Private households with employed persons*” and B “*Fishing*” revealing a misbalance in the way each section branches out.

Furthermore, we observe that the section D “*Manufacturing*” mainly branches out at the division and group level while section G “*Trade*” branches out at the class and subclass level. The nature of the activity clusters is the explanation of this difference. This reflects the traditional interest in statistical data on manufacturing, and it also reflects that the nature of manufacturing is very diverse considering the production processes. The activities of Trade are to a large extent similar at higher aggregation levels. The branching out is only determined by the type of goods (on sale).<sup>7</sup>

<sup>7</sup> Source: expert interview Statistics Netherlands (drs. Hans van Hooff)



**Figure 7: Visualisation SBI 2008**

In Figure 7 we see a plot of the SBI 2008 classification. It consists of 21 planar tree structures. The hierarchy is similar to the previous plot (section, division, group, class and subclass). The number of sections has increased from 17 (SBI 1993) to 21 (A to U, see Figure 7 on the right hand side). Furthermore, we observe that the way it branches out is more homogeneous compared to SBI 1993. In SBI 2008 more emphasis was put on services instead of production of goods compared to SBI 1993. Generally, services are spread out widely in all sections where production of goods is concentrated in one large section (D in SBI 1993 and C in SBI 2008).

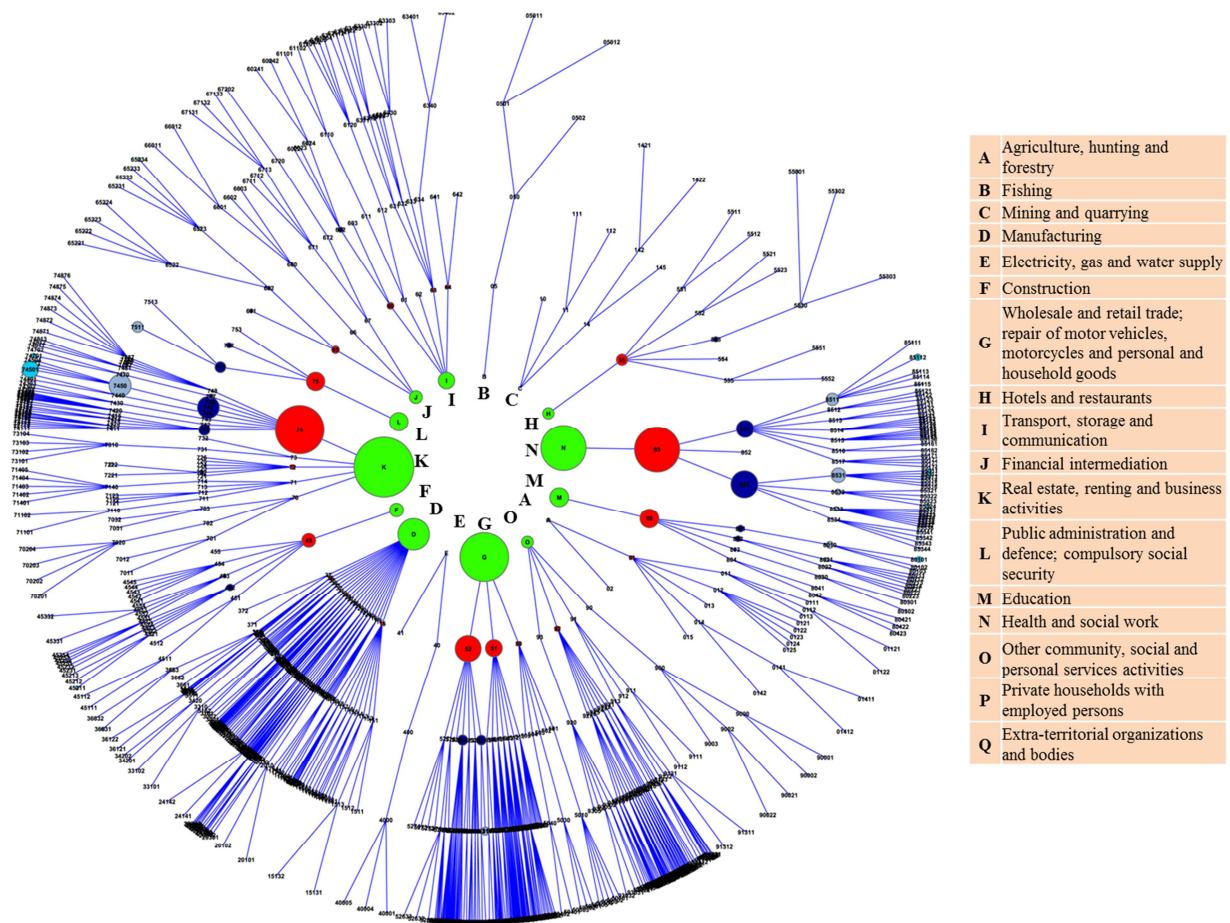
Looking at branching properties, an exception is observed concerning section “U. *Extraterritorial organisations and bodies*” that consists of a non-branched tree. Furthermore, section A “*Agriculture, hunting and forestry*” and B “*Fishing*” of SBI 1993 have been merged in to section A “*Agriculture, forestry and fishing*” of SBI 2008. Section C “*Manufacturing*”, is again the most densely branched section.

In both SBI classifications we have seen, an inside out approach is used to classify. It starts with the inward ring (green ring), when it is defined other divisions can be classified under these sections. In SBI 2008 a new residual section S is introduced that was not defined as such in SBI 1993. SBI 2008 section S “*Other service activities*” was defined in SBI 1993 section O as a division, note that never anyone says to work in the sector “*Other service activities*”.

When creating a more homogeneous classification standard, a larger residual part is inevitable. The activities causing heterogeneity are concentrated together as a consequence of introducing more homogeneity in all other sections.

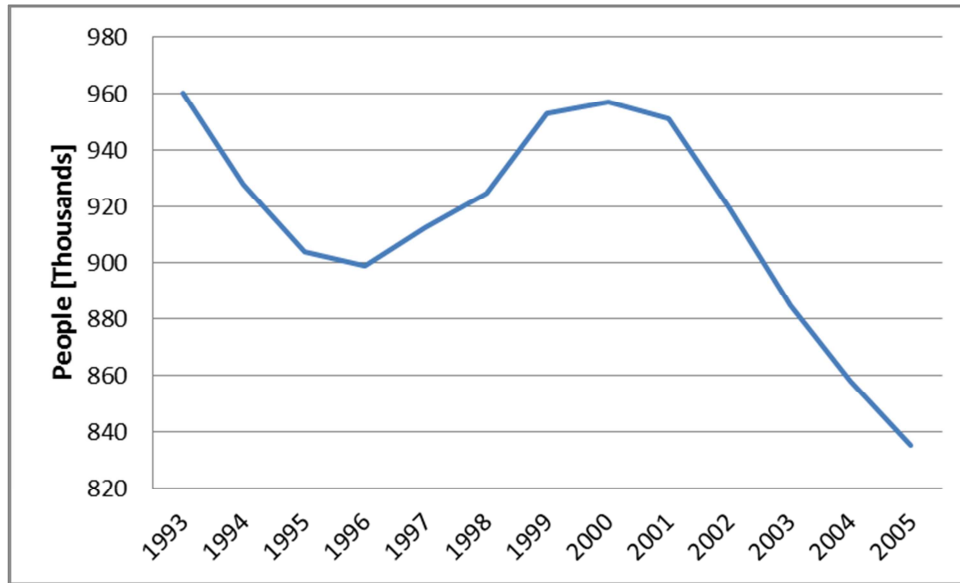
### 3.1.3 Working People in The Netherlands

A characteristic of Western societies such as ours is that we are strongly dependent on our infrastructures, such as electricity, transport, telecom, etc. This applies to households, but as well for organisations. These infrastructures are increasingly intertwined with each other. A further characteristic of these infrastructures is that the main parts are currently led by private parties.



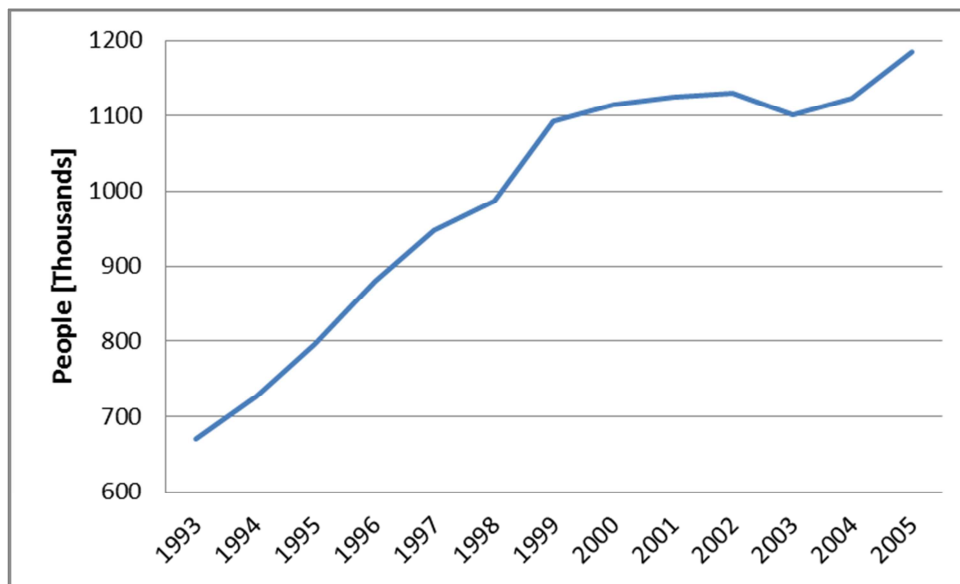
**Figure 8: Working People in The Netherlands in 2007 based on SBI 1993**

Figure 8 plots the Working People in The Netherlands (year 2007), on the tree structure of SBI 1993. In this plot relative size of the circles reflects the numbers of working people in each activity cluster. The largest number of employees is found in the section K “Real estate, renting and business activities”. However, the branching is relatively thin, and particularly the employment agencies are the largest division in this section. Section K is commonly referred to as “business services” as well. Second and third major sectors (in WP 2007) are Trade and Healthcare respectively. Then there follows the Manufacturing and Education sections. Similar to the data set of WP 2007, we did the same to the data set of 1993-2005 and plotted each year, and collected it in a small animation to visualize the change in WP in the course of years. This animation (WP) is available via the website of NAS: <http://www.nas.its.tudelft.nl>



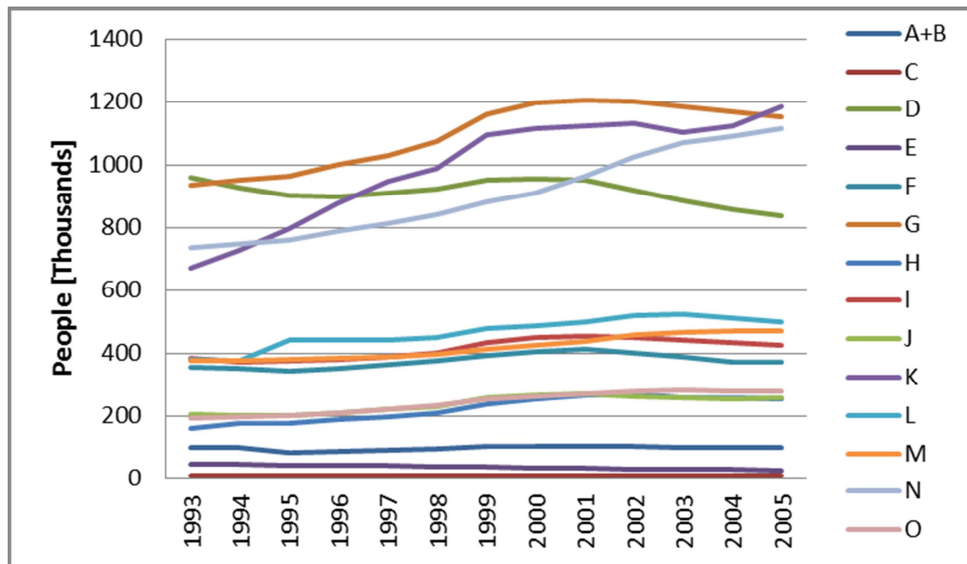
**Figure 9: Number of working people in section D “Manufacturing” of SBI 1993**

Figure 9 shows the number of working people in section D “Manufacturing” of SBI 1993 in the period of 1993-2005. This shows that the number of working people is dramatically decreasing in “manufacturing”. The causes of this decrease could be either automation or outsourcing of production related labour to countries where production salaries tend to be lower than those in the Netherlands.



**Figure 10: Number of working people in section K “Business services” of SBI 1993**

Figure 10 shows the diagram of the number of working people in section K “Real estate, renting and business activities” of SBI 1993 in the period 1993-2005. This shows a fast increase of the number of working people in this section. Namely, the increase in employment agencies and business services is the cause of this growth.



**Figure 11: Number of working people in each section of SBI 1993**

Figure 11 shows the number of employees in each section of SBI 1993. This diagram shows that section G “Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods” contained less people than section D “Manufacturing” from 1993 until 2004, but it converses in the year 2005. Furthermore, the number of working people in section N “Health and social work” is increasing fastest comparing to other sections.

### 3.1.4 Input Output table

Input-Output tables (I/O) are the statistical reports on production and use of goods and services to different activity clusters and also contain specifications of the components of final spending's, such as consumption, exports, investments and change in stocks. The main purpose of an input-output table is to provide insight into the production structure of an economy: who produces what, and who uses it. The value and nature of production and use of goods and services are identified in this way. Furthermore, the relationships between the various activity clusters are established. The classification of companies in the corresponding classes is of particular importance. In the Dutch input-output table firms are grouped based on characteristics of production technology and product type. There is no distinction made between different sizes: small and large companies with the same characteristics are located in the same enterprise-class [12].

An input-output table expresses in monetary terms the overview of product flow within and between activity clusters for a certain period of time (one year). The table can be divided into four quadrants:

- Top left is the internal and intermediate deliveries of the various industries, the supply of a particular sector to the private sector and all other sectors;
- Bottom left are the primary costs, the cost of imports and labour and other costs (capital costs and depreciation, value added);
- Top right, the final distribution, consumption, investment and exports;
- Bottom right, are the primary costs which are flowing directly as final disposal, these are often set to zero.

Each row of the input-output table records the production of a given activity cluster divided into expenditure categories: intermediate consumption of other activity clusters and final expenditure [12]. The columns of intermediate consumption is described by the activity cluster (or imports) by the business class products used come. For example, in cell 50,74 the product consumption of “electricity, gas, steam and air conditioning supply” by the “telecommunications and post” are measured. Conversely, the cell 74,50 describes the import of goods and services from “telecommunications and post” toward “electricity, gas, steam and air conditioning supply”.

Statistics Netherlands provided a data set that aggregates all monetary transactions observed over the period 1987 - 2007 in The Netherlands among 105 different activity clusters. In this study, each node represents an activity cluster. Subsequently, these 105 nodes can be classified and merged into 20 sectors. The millions of euros that traverse the links quantify the produced and consumed value by the nodes. Analysis of this sector network is in the first place interesting to translate the complex network parameters to the economic meanings. Second it will help to enhance the description of Complex Networks. Analysis can be carried out in each dimension independently. Over the past several years, a variety of measures have been proposed to capture different features of a network topology.

## 3.2 Vital Sectors

### 3.2.1 Sector identification by the Dutch Ministry of Interior Affairs

The Dutch Ministry of Interior Affairs (MinBZK) has listed and analysed the vital sectors and their products and services aiming to improve the vital infrastructure governance within The Netherlands. This activity is a part of the Crisis treatment / Risk management program. According to MinBZK, vital infrastructures are often in control of the companies themselves. In those cases, the government heavily depends on the ability and commitment of the industry [13].

**Table 3: Vital sectors, products/services [13]**

|           | <b>Sector</b>                        |           | <b>Product/Service</b>  |
|-----------|--------------------------------------|-----------|---|
| <b>1</b>  | Energy                               | <b>1</b>  | Electricity   |
|           |                                      | <b>2</b>  | Gas   |
|           |                                      | <b>3</b>  | Oil   |
| <b>2</b>  | Telecom                              | <b>4</b>  | Fixed telecommunications  |
|           |                                      | <b>5</b>  | Mobile telecommunications   |
|           |                                      | <b>6</b>  | Radio communications and navigation   |
|           |                                      | <b>7</b>  | Satellite communications  |
|           |                                      | <b>8</b>  | Broadcasting  |
|           |                                      | <b>9</b>  | Internet access   |
|           |                                      | <b>10</b> | Postal and courier services   |
| <b>3</b>  | <i>Drinking water</i>                | <b>11</b> | Drinking water supply   |
| <b>4</b>  | <i>Food</i>                          | <b>12</b> | Food supply / - Safety  |
| <b>5</b>  | Healthcare                           | <b>13</b> | Urgent care / other hospital care   |
|           |                                      | <b>14</b> | Medicines   |
|           |                                      | <b>15</b> | Sera and Vaccines   |
|           |                                      | <b>16</b> | Nuclear Medicine  |
| <b>6</b>  | Finance                              | <b>17</b> | Payment services / payment structure  |
|           |                                      | <b>18</b> | Government financial transfers  |
| <b>7</b>  | <i>Managing surface water</i>        | <b>19</b> | Managing water quality  |
|           |                                      | <b>20</b> | Managing and control of water quantity  |
| <b>8</b>  | <i>Public Order and Safety</i>       | <b>21</b> | Maintaining public order  |
|           |                                      | <b>22</b> | Maintaining public safety   |
| <b>9</b>  | <i>Legal Order</i>                   | <b>23</b> | Justice and detention   |
|           |                                      | <b>24</b> | Law Enforcement   |
| <b>10</b> | <i>Public Administration</i>         | <b>25</b> | Diplomatic Communications   |
|           |                                      | <b>26</b> | Government Information  |
|           |                                      | <b>27</b> | Military  |
|           |                                      | <b>28</b> | Decision making public administration   |
| <b>11</b> | Transport                            | <b>29</b> | Main Port Schiphol  |
|           |                                      | <b>30</b> | Main Port Rotterdam   |
|           |                                      | <b>31</b> | Highways and main waterways   |
|           |                                      | <b>32</b> | Railways  |
| <b>12</b> | <i>Chemical and nuclear industry</i> | <b>33</b> | Transport, storage and production / processing of chemical and nuclear substances |



The report of 2005 is a quick scan of the government to get an overall view. This is done before the sectors individually starting with the analysis of their divisions. This quick scan has led to the classification in 12 vital sectors that are further broken down into 33 vital products and services, which we can see in Table 3. We speak of vital infrastructure, belonging to vital sectors, when it comes to products, services and underlying processes which may lead to social disruption if they were to fail. This may be because there are many victims and economic losses, or restoring lasts long and there are no real alternatives, while we cannot miss these products and services [5]. Vital sectors such as Energy, Telecom, Transport, Healthcare and Drinking water, form an important link in Dutch society while protecting their IT systems and information is vital. Vital sectors are therefore crucial for the proper functioning of the Dutch society. A number of vital sectors are in the hands of the government, such as Managing and control of surface water (including the dikes) and Public Order and Safety (fire, police and medical disaster relief and crisis). Because 80% of the vital infrastructures is in the hands of companies, a close collaboration between government and industry required [5].

#### **Energy Sector (according to the Dutch Ministry of Interior Affairs)**

A secure supply of energy to society is very important. Within the energy sector, the vital products are natural gas, electricity and oil, which need high supply guarantee. The supply and availability of these fuels are important for households, government and industries. Almost all the vital products and services have a high degree of dependence on one or more of these fuels. Supply via the networks and infrastructure for the Energy sector is not only important for the national supply, but also of great international importance [5].

#### **Telecom Sector (according to the Dutch Ministry of Interior Affairs)**

The Telecom sector is fulfilling an increasingly significant role in everyday life. This sector, “Telecom” for simplicity, involves a wide range of services, processes and infrastructure. The accessibility and quality of this sector are very important for civilian, government and business activities. In addition, the telecommunications must be reliable, highly available and should be safe to use. This also applies to networks and services with no limitation to national or international operation.

The providers of telecommunication services have the responsibility to ensure a good continuity of their services. Due to commercial interest these providers are highly interested in preservation of their telecommunications facilities. This means that they actively take actions where necessary. Companies that offer Internet access (ISPs) have a high awareness of risks because of the many daily attacks on the system. The telecom companies have mutually resolved the prevention of possible damage to many systems [5].

#### **Drinking Water Sector (according to the Dutch Ministry of Interior Affairs)**

Drinking water sector is a basic human need. In the Netherlands drinking water is in addition to consumption by humans also used for other domestic purposes like process water sanitary use, fire fighting water and water for animals. The continuity and quality of supply of drinking water is well regulated for years. Agriculture though consumes by far the largest percentage of water [5].

#### **Healthcare Sector (according to the Dutch Ministry of Interior Affairs)**

The healthcare sector could face difficulties due to failures in other sectors (energy, water, telecom, transport) or causalities caused by deliberate human action. The failure of healthcare has no direct impact on the level of “vital” for the other sectors, but directly effects the survival of citizens. The Healthcare sector is like every other sector, increasingly dependent on electronic information sharing. Relevant roles in the Healthcare sector are: patient care, consumer, healthcare provider, care agency, insurer, drugstore, laboratory, medical scientist, equipment and materials suppliers, logistics or administrative service and others [5].

### **Finance Sector (according to the Dutch Ministry of Interior Affairs)**

Due to the great many transactions that take place in the Finance sector, the financial-economic consequences and social discomfort can rise up very fast when there is a failure. Unlike the example of Drinking water sector or the Energy sector there is no direct human or animal life association with failure or disruption of the Finance sector. The chain effects of failure of the Finance sector are more limited than in the case when network infrastructures (such as the electricity sector or the telecom sector) would be the case. Chain effects mainly occur in large-scale loss of pin-facilities of the counter payments.

The operation of the infrastructure, data storage and data traffic and electronic services in the Finance sector is potentially vulnerable to computer malfunctions, viruses, cybercrime and hacking. In general, the impacts of such incidents for the vital processes in the Finance sector are relatively low, and they do not jeopardize the vital services in the long term.

Fraud and crime can lead to shifts in the level of services in the Finance sector, to be considered as vital. They have a significant impact on the trust people have in electronic services or Internet payments. There is however, no disturbance of macro-scale yet. In large-scale terrorism the continuity of the Finance sector is not fully guaranteed. However, in the Finance sector, backup and disaster recovery centres are settled. Risks can never be ruled out entirely. Moreover, the Finance sector is a dynamic sector in which rapid developments take place [5].

### **Managing surface water Sector (according to the Dutch Ministry of Interior Affairs)**

A major concern of government is to protect the country against flooding and the presence of sufficient clean water for all users. Flood protection is achieved by maintaining the construction of dams. A distinction is made in four categories [5]:

1. A primary water defences: flood protection from the big rivers, lakes and the sea;
2. Regional water defences: protection against flooding from regional waters;
3. Drainage: drain the hinterland for protection against flooding;
4. Water quality: prevention of large-scale pollution of surface water.

### **Legal Order Sector (according to the Dutch Ministry of Interior Affairs)**

Whenever there is an emergency it is the judicial responsibility that justice can take place sufficiently and that the “closed” facilities are not “a little” open. In the report of MinBZK specifically addresses the three subsectors of the Legal Order Sector [5]:

1. The Public Prosecution: the Public Ministry is a national organization with a total of one hundred establishments in the Netherlands.
2. The Council for the Judiciary: The judiciary is largely dependent for its normal functioning of the vital sectors: energy, telecommunications and drinking water.
3. Judicial Institutions Services: the vital importance of this subsector follows from the fact that it would be disruptive if the judicial institutions would fall. Some of the detainees constitutes a danger to our society and can cause big problems if they are not incarcerated.

### **Public Administration Sector (according to the Dutch Ministry of Interior Affairs)**

The public administration sector plays a special position in the Critical Infrastructure Protection Project. Whenever there is a large-scale disaster such as catastrophic terrorist attacks, natural and industrial disasters, the government, in this case the Public Administration is responsible for the integral care for the public order and safety. The effects of a disturbance in random vital sector inherently become the responsibility of public administration. Given that in almost every crisis there is a direct relationship with the public administration and / or public order and safety. There is always necessary to coordinate the Ministry of Interior affairs and Kingdom Relations [5].

### 3.2.2 Vital Sector Analysis

#### Revision MinBZK Vital Sector list with SN experts

In Table 3 (vital sectors according to the Dutch Ministry of Interior Affairs) the sector names mentioned below are written in italics because they are not commonly recognized as sectors in many different national classification systems. Another important fact is the term “Telecom” is not mentioned at the section level in ISIC. The main consensus issue centres around the addition “tele”. ISIC 1993 and ISIC 2008 both give the name “Communications”. ISIC 2008 refers to “Information & Communication”. Thus taking the above into account we propose to adjust:

- Drinking water
- Food
- Managing surface water
- Public Order and Safety
- Legal Order
- Public Administration
- Chemical and nuclear industry

Having consulted classification experts<sup>8</sup>, in this thesis we propose to simplify the sector names from table 3 [5] of the vital sectors to more commonly accepted names used in the most prevalent classification systems:

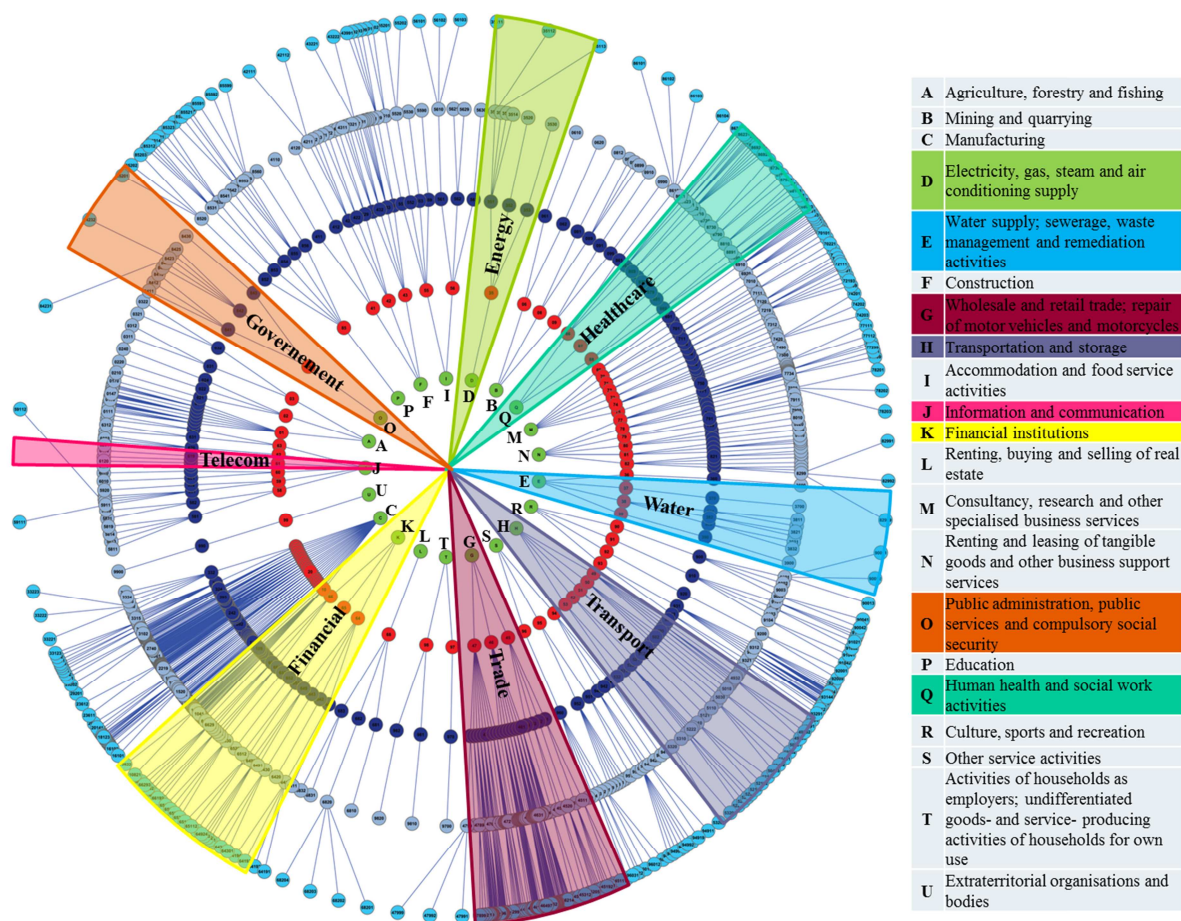
- Merge the four MinBZK defined vital governmental sectors (Managing surface water, Public Order and Safety, Public Administration and Legal system) into one “government sector”[6].
- The (MinBZK defined) food sector is repositioned as part of the Trade sector, because the Trade sector directly supplies food to the citizens [6].
- The (MinBZK defined) “Chemical and nuclear industry” sector is removed, because it is only one of the 33 divisions in the ISIC section D “*Manufacturing*”.

An important observation is the fact that the Ministry of Internal Affairs does not explicitly mention the Household as a vital sector. Later on in this sub-paragraph this issue is discussed, but after the proposed revision above, we can add eight vital sector names on the plot of the SBI structure and conclude that a minority of all activity clusters can be labelled as vital.

---

<sup>8</sup> According to insights from:

- On-going research PhD project E. van Boven
- Statistics Netherlands classification experts



**Figure 12: Vital sectors plotted on the SBI 2008 classification**

Figure 12 shows the vital sectors plotted on the SBI 2008 classification. According to ISIC, telecom is a division. At the section level, the United Nations preferred the term Information and Communication. Although the size of Telecom in the number of working people and the economic value in monetary terms is a relatively small part of the total economy, the MinBZK defines telecom as a vital sector, because the vital sector Telecom provides a vital infrastructure, where all the sectors depend on.

### Household considered as a vital sector

Household as a section was defined in ISIC 1993 (section P “*Private households with employed persons*”) and in ISIC 2008 (section T “*Activities of households as employers; undifferentiated goods- and service-producing activities of households for own use*”). Statistics Netherlands adopted this definition in SBI 1993 and 2008 respectively. Furthermore, Economic Glossary already defines household as a sector:

*“The basic macroeconomic sector that includes the entire, wants and-needs-satisfying population of the economy. The household sector is the eating, breathing, consuming population of the economy. In a word “everyone”, all consumers, all people. This sector includes everyone seeking to satisfy unlimited wants and needs. While it’s called “household” sector, this doesn’t require that you own a house, live in a house, or even know someone has ever seen a house to be included. The term household sector is merely a short-cut used by economists to indicate the consuming, wants-and-needs-satisfying population.”<sup>9</sup>*

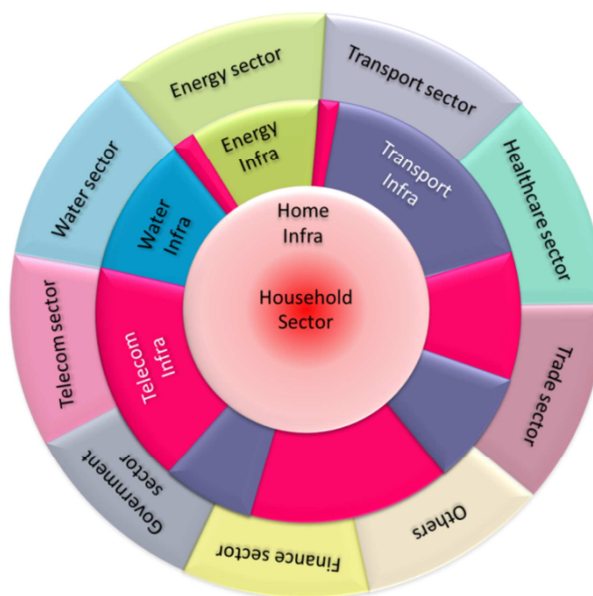
<sup>9</sup> Source: <http://glossary.econguru.com/economic-term/household+sector>

Traditionally, the household was thought to be inhabited by people solely in their role of consumer. Over the last three decades however some people enriched this private role with more active and or productive aspects. This role enhancing development is commonly referred to with the term “prosumer” which is a contraction of “pro” and “consumer”. To find out more about the definition of the term “prosumer” a quick scan (Wikipedia) resulted in a few different options to choose from:

- Progressive consumer
- Professional consumer
- Provider consumer
- Pro-active consumer
- Producer consumer

For the first time ever futurologist Alvin Toffler coined the term “prosumer” in his book, *The Third Wave* (1980) [62]. Toffler predicted that the role of producers and consumers would begin to blur and merge. He showed that the industrial way of thinking and organizing will not continue. The emergence of information technology creates the “prosumer community”: the abolition of the distinction between consumer and producer. This waiver will ensure that consumers no longer influenced by institutions, but they build their own identity. The consumer becomes integrated in the production process. He or she wants to solve a question or problem in cooperation with the manufacturer or supplier. At the end of this process it is not clear who was the producer and who the consumer. They both have their influence and are both responsible for the end result. The term “prosumer” really came to life by the market research conducted in 2004 of Euro RSCG: “*Prosumer Pulse 2004: A Global Study-Anticipating Consumer Demand*” [61]. This research shows that prosumers are spearheading the group of consumers. They are driven by three forces:

- Internet (supports them with information, forums and communication)
- Media fragmentation (makes their word-of-mouth influence much larger)
- Globalization on a personal level (they have the global opportunity to influence)



**Figure 13: The home in the sector network**

Figure 13 shows the Household as a junction for the majority of all sectors (thus both vital sectors and other non-vital sectors). Some vital sectors are directly connected to the household via their own infrastructures. The government, healthcare, trade and finance sector as well as the majority of all other non-vital sectors (e.g. Entertainment, Education, etc.) connect to the household via the Telecom, Energy and Transport infrastructures.

*“This domestic sphere has previously been seen as outside the economy, as too complex and ungovernable, but has come now to be recognised as critical economically, with all the needs of support, tools, skills and advice that being a producer entails.” [67]*

Knowing that in the Netherlands a household consists of 2.22 persons on average and about 7.3 million out of 16.4 million people work, there is a huge inter-dependence between the Household sector and all other sectors functioning. As more and more people work from their homes, the quality and availability of the household infrastructure (e.g. the home network which is heterogeneous in nature) becomes more and more vital to society and economy as a whole. Without this high availability home infrastructure, the robustness of all sectors is at stake. Thus, the household can be defined as a vital sector for several reasons, for example:

1. The household is the basis for all people in their private roles
2. The household provides the workforce for all other sectors.
3. The availability and functionality of home networking is becoming increasingly important (many crucial activities are conducted from home, e.g. working at home).
4. Production for own use cannot be classified in other sections.
5. Many private-role driven activities are performed by households (e.g. renting rooms, generating energy, bartering goods and labour and providing services to other households) these activities are part of the informal economy which is neither taxed nor monitored by authorities, and not included in official statistics.

The output and activities of the majority of all other sectors enter the households.

### **The most important economic characteristic of Household sector**

The two most important economical characteristics of the Household sector are:

1. They are the workforce of all other sectors, so they largest amount of money is coming toward the household (salaries)
2. They are the largest consumers of all other sectors, by spending money on all services and products of all other sectors.

However in the classification systems these two properties are not counted to household (section). Therefore Statistics Netherland does not count the mentioned monetary transactions as “the internal and intermediate deliveries” in the I/O table (which are in the top left of the I/O table). The household spending is separately taken out in a single column 107 “final consumption expenditure of households”. And the received salaries of households are counted in row 118 “salaries”, which is outside the 104 by 104 matrix of “the internal and intermediate deliveries”.

In this thesis we explicitly add household spending and salaries in one matrix with the “the internal and intermediate deliveries” (104 by 104) of other activity clusters. So the input-output matrix that we will used in the rest of this thesis is 105 by 105, whereby the 105<sup>th</sup> row corresponds to the “final consumption expenditure of households” (because it is the money that household delivers or “expends” to other activity clusters), and 105<sup>th</sup> column correspond to the “salaries” (which is the money coming to household sector by all other activity clusters). In the rest of this thesis research we will investigate the economic vitality of the Household sector for the sector network.

### **3.2.3 Dependencies of the vital sectors**

In order to be able to abstract the important relations and dependencies of the vital sectors we took a revised set of vital sectors of MinBZK, and put them in an adjacency matrix. This information will help us to select the important business and society related properties of the sectors, and to find out what every vital sector gives to or takes from other vital sectors in high level abstraction.

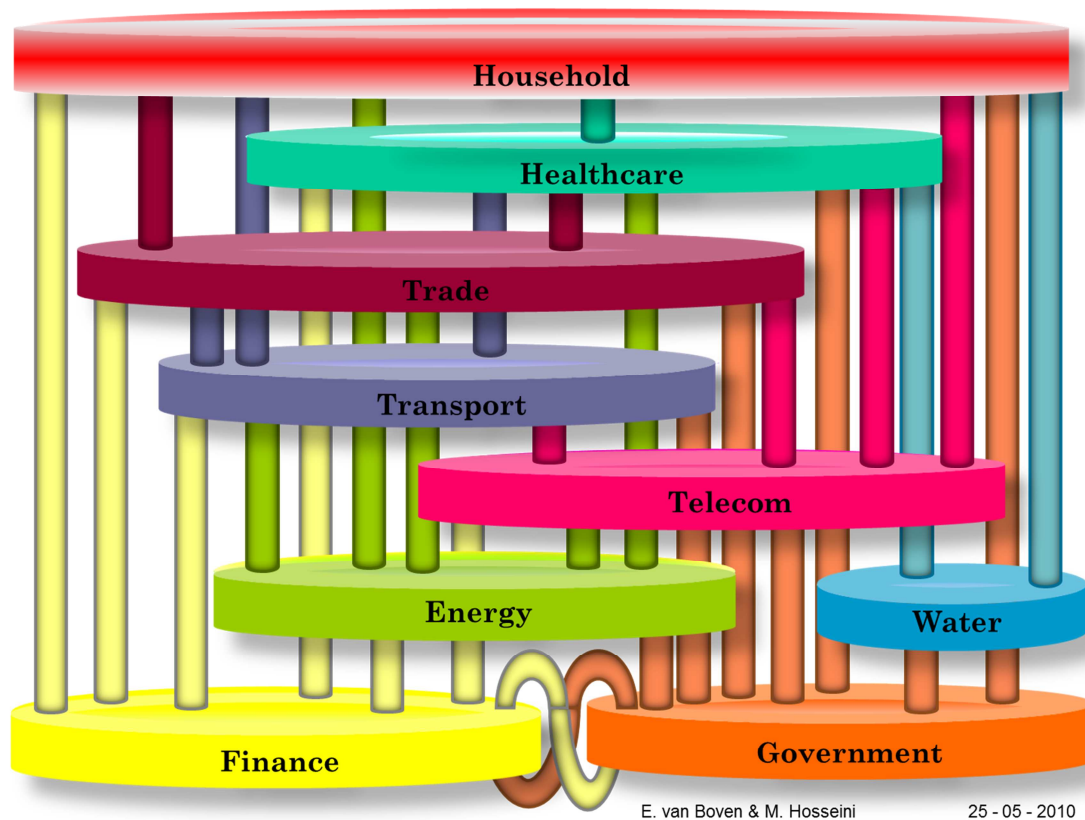
For research feasibility reasons and classification correctness, we propose a revised vital sector relation matrix:

- The four (MinBZK defined) Government vital sectors are merged into one.
- The (MinBZK defined) food sector is repositioned as part of the Trade sector, because the Trade sector directly supplies food to the citizens.
- The (MinBZK defined) “Chemical and nuclear industry” sector is removed, because it is an ISIC division and because it is not directly related to the household.

**Table 4: vital sectors using Ministry of Interior Affairs definitions**

| Relations<br>Vital sectors<br>derived from<br>MinBZK | Energy  | Telecom                             | Water  | Trade   | Healthcare   | Finance   | Government  | Transport   | Household  |
|--|---|-------------------------------------|--|---|--|---|---|---|--|
| Energy   |   | electricity                         | electricity, gas   | electricity, gas  | electricity, gas   | electricity   | electricity, gas, oil   | electricity, gas, oil   |  |
| Telecom  | fixed and mobile telecom., internet, postal and courier |                                     |  | fixed and mobile telecom., internet, postal and courier | fixed and mobile telecom., internet, postal and courier            | fixed and mobile telecom., internet, postal and courier | fixed and mobile telecom., internet, postal and courier, broadcasting | fixed and mobile telecom., internet, postal and courier, radio communications and navigation          | fixed and mobile telecom., internet, postal and courier, radio communications and navigation |
| Water  | drinking water supply                                   | drinking water supply               |  | drinking water supply                                   | drinking water supply  | drinking water supply                                   | drinking water supply   | drinking water supply   | drinking water supply  |
| Trade  | food supply /-safety                                    | food supply /-safety                | food supply /-safety   |   | food supply /-safety   | food supply /-safety                                    | food supply /-safety  | food supply /-safety  | food supply /-safety   |
| Healthcare   |   |                                     |  |   |  |   | urgent care / other hospital care                                     |   | urgent care / other hospital care  |
| Finance  | payment services, payment structure                     | payment services, payment structure | payment services, payment structure                          | payment services and structure                          | payment services, payment structure, government financial transfer |   | government financial transfer   | payment services, payment structure   | payment services, payment structure  |
| Government   | licenses, regulation                                    | licenses, regulation                | managing water quality, water quantity management and return | safety and responsibility of food production            | administration and policy, laws and regulations                    | legislation, diplomatic communications                  | all government services and products                                  | maintaining public order, public safety enforcement, justice and detention, administration and policy | public information, maintaining public order, public safety                                  |
| Transport  | highways, main waterways, railways                      |                                     |  | highways, main waterways, railways, main ports          | highways, main waterway  | highways, main waterways                                | highways, main waterways, railways, main ports                        |   | highways, main waterways, railways   |
| Household  | <b>W</b>  | <b>O</b>                            | <b>R</b>   | <b>K</b>  | <b>F</b>   | <b>O</b>  | <b>R</b>  | <b>C</b>  | <b>E</b>   |

Our proposed relation matrix has been reviewed and revised in cooperation with an SN expert. Finally, we used the revised relation matrix to produce a hierarchic graph that reflects the vital sector dependencies in a vertical sense.



**Figure 14: Hierarchic graph of the vital sectors<sup>10</sup>**

Figure 14 shows the main dependencies of the vital sectors in a hierarchic graph concept. The columns in the graph indicate the relationship of each sector (node) to another. On top, we see the Household sector, to which all other sectors provide value (a service and/or product). This hierarchic graph shows the important dependencies between the vital sectors, e.g. without Transport and Telecom sector the Trade sector cannot proceed functioning, without Energy sector the Telecom sector cannot function (a high amount of electricity is used by Telecom sector).

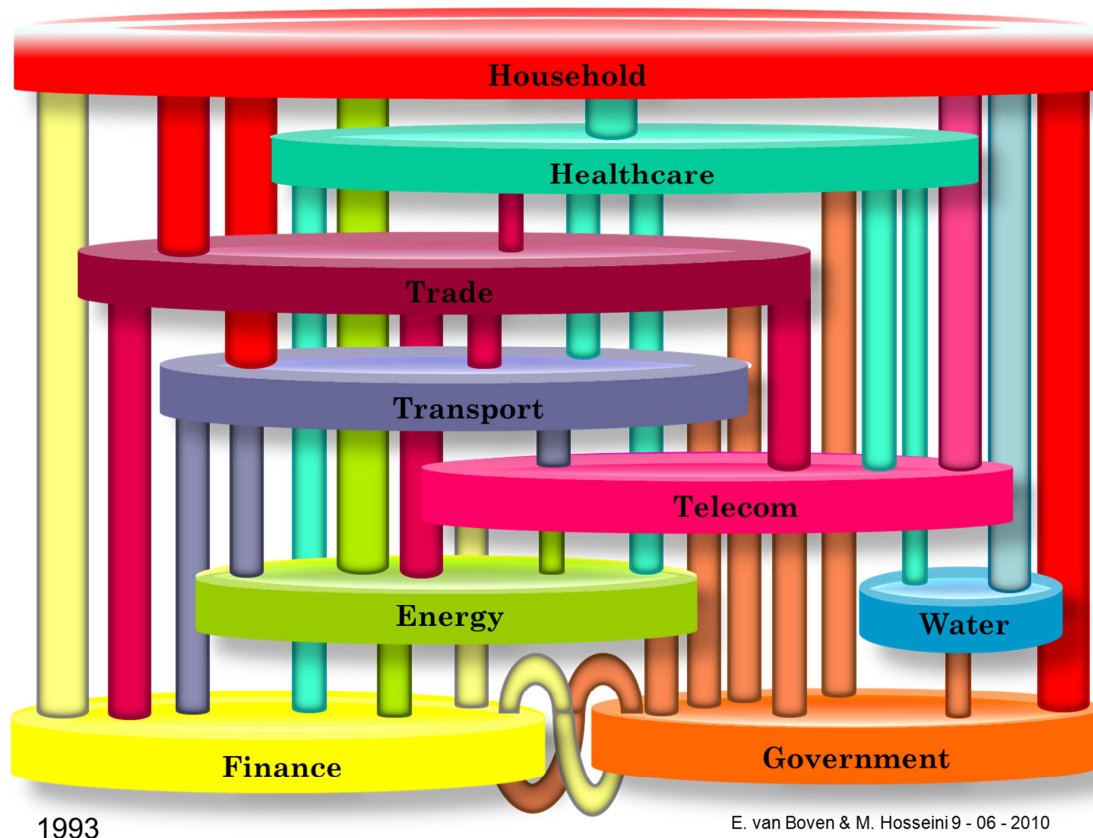
Furthermore, in the graph no link is shown between Water and Energy sector. This is done for the sake of clarity. However, energy supply is very essential to purify water, so the amount of money transacted from Water to Energy is quite large. Furthermore, we depicted dependency relations for Government and Finance on the same height because it is unclear which one is more dependence of the other.

<sup>10</sup> E. van Boven and I propose this novel hierarchic graph concept. This new type of graph depicts the hierarchical structure and the main dependencies of a network in a vertical sense. Though nodes can have inter-dependencies (bidirectional), we discovered one dependency dominant in economic network.



### 3.3 The Dutch economy as a monetary transaction network

#### 3.3.1 Monetary dependencies of the vital sectors



**Figure 15: Hierarchic graph of the vital sectors (bidirectional graph)**

#### Monetary transactions (Input Output table)

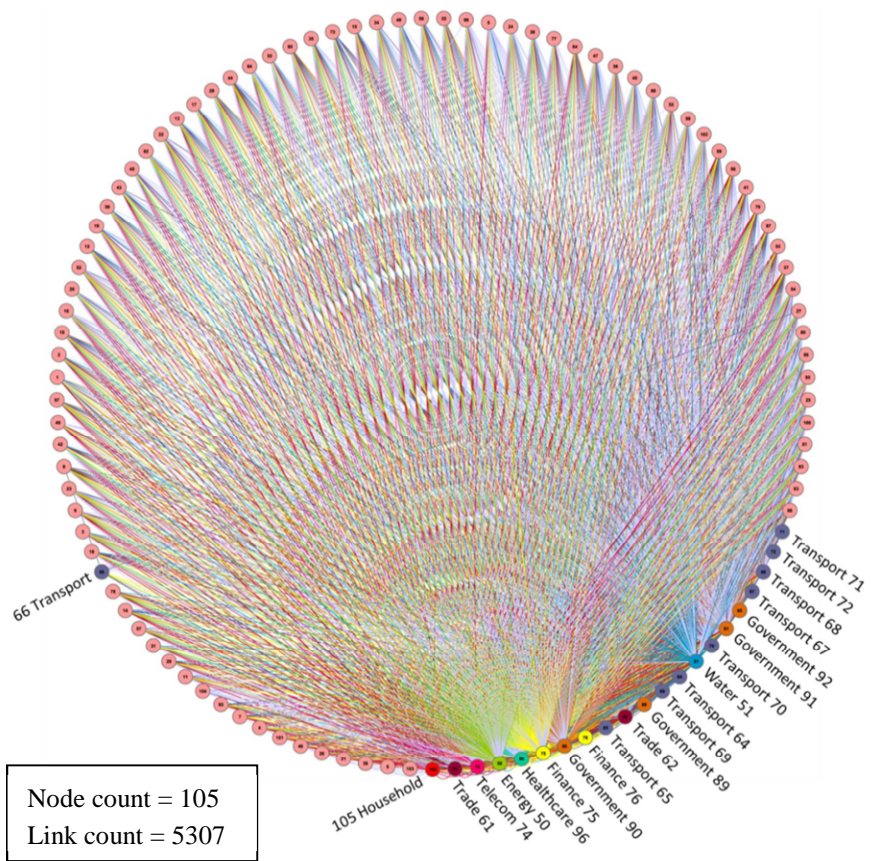
From the 20 sectors defined (see section 2.1, Figure 2), nine sectors can be labelled as vital sectors (after consulting SN expert). These nine have been given a unique colour each. Figure 15 depicts the same hierarchic topology as Figure 14. In This version the link weights are reflected in the thickness of the links. Furthermore, the links are bidirectional and the dominant monetary transaction direction determines the colour of the link. E.g. the monetary transaction volume from Trade to Finance is larger than the volume in the opposite direction. Therefore, the connecting link between Trade and Finance is given the colour purple.

#### 3.3.2 Monetary connectedness of the vital sectors

In this subparagraph, we consider the I/O table monetary transaction dataset as a network. Thereby, each activity cluster is seen as a node and each monetary transaction as a link. The same vital sector colours are also attached on the activity cluster level (105 nodes) thus showing their links (relations) as well. Furthermore, the nodes are plotted in the order of increasing degree (clock wise). The household activity cluster 105 always shows the highest degree compared to all other activity clusters. In subparagraph 3.3.2 and 3.3.3 non-vital sectors / activity clusters are plotted in a pink colour and their links light blue. An overview of the number of each activity refers to Table 8 in the appendix.

**Link weight  $\geq 1$  million €**

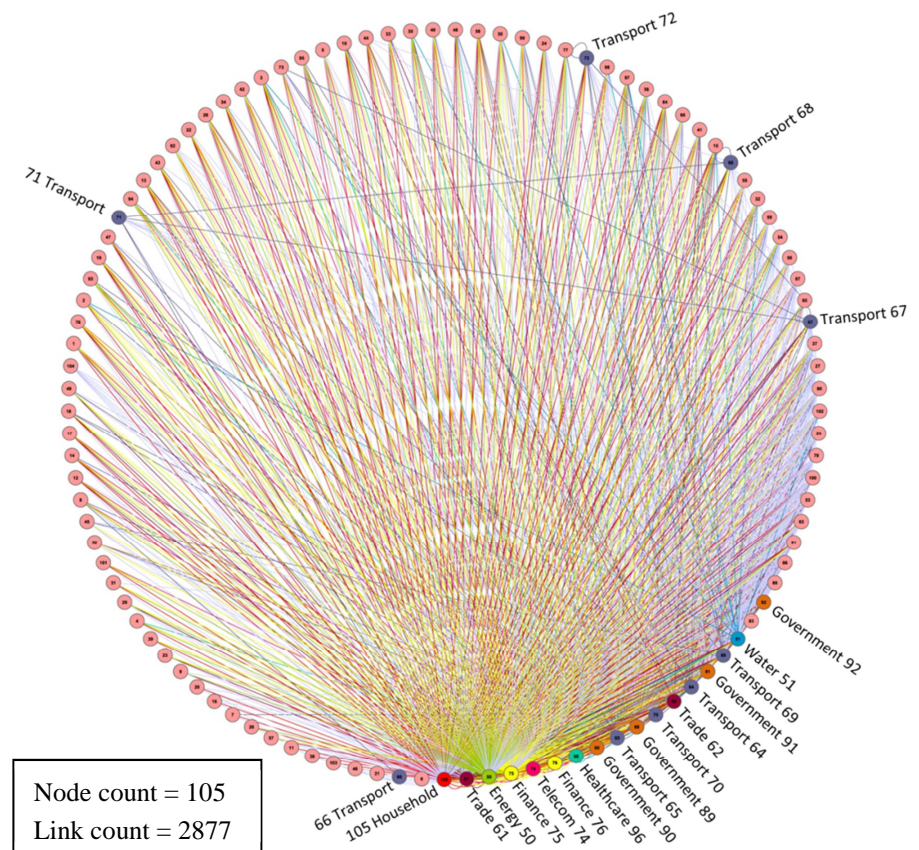
The first plot shows all the unidirectional link weights between 105 nodes where the amount of link weight is greater than or equal to 1 million euro. Here the number of links is equal to 5307, which means that in the year 2007, there were 5307 transaction links between all activity clusters of the weight 1 million and higher. In this plot, we see the degree ranking of nodes corresponding to the vital sectors. We know that Household node 105 (colour red) is the most connected node, because of salaries and spending. If we shift one node counter clockwise we come across the node 61 which is part of the Trade sector, and the third node we see is the node 74 corresponding to the Telecom sector. This corresponds with the whole sector because Telecom consists of one node. Note that the Post is also included in the node 74.



**Figure 16: Money transaction network 2007 (link weight  $\geq 1$  mln)**

**Link weight  $\geq 10$  million €**

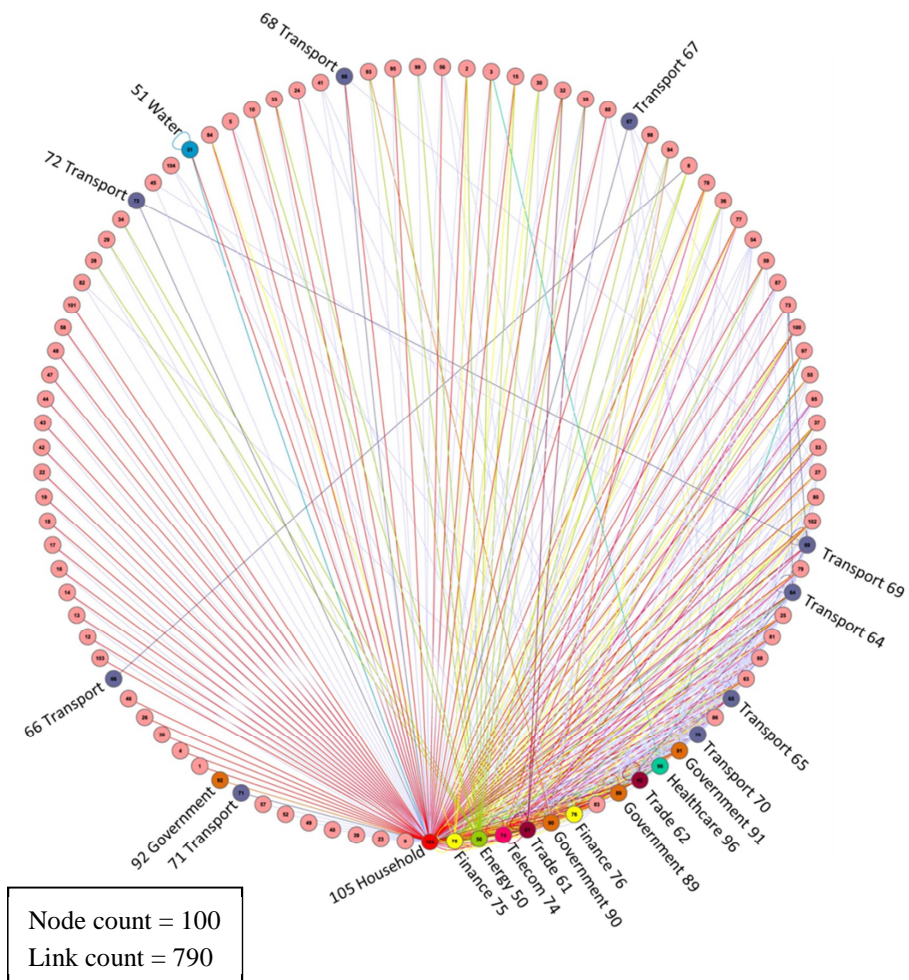
In this plot, we see the link weights greater than or equal to 10 million euro. If we compare this plot with Figure 17, we see some shifts in the sequence of the activity clusters while the number of nodes is still 105 and number of links is 2877. For example, the banking node 75 of the Finance sector (yellow) has more links than the Telecom node 74 (pink), also Energy (node 50) is shifted one to the right which means it is stronger connected in larger transactions.



**Figure 17: Money transaction network 2007 (link weight  $\geq 10$  mln)**

**Link weight  $\geq 100$  million €**

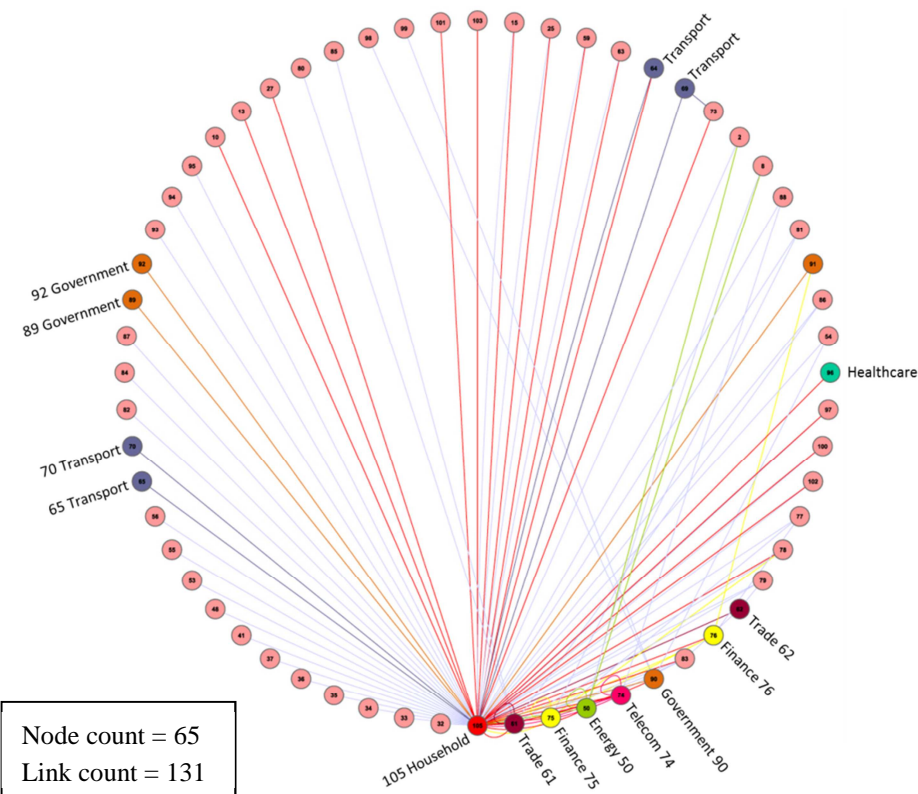
This plot shows the link weights greater than or equal to 100 million euro. We see the number of nodes decreasing to 100, which means that five nodes have no connections equal or larger than 100 million. Furthermore, the link count is appropriately decreased to 790, which means that in this range a small number of large transactions. The node 75 of Finance takes the second, Energy the third, Telecom the fourth and Trade the fifth positions in degree ranking for large transactions.



**Figure 18: Money transaction network 2007 (link weight  $\geq 100$  mln)**

**Link weight  $\geq 1$  billion €**

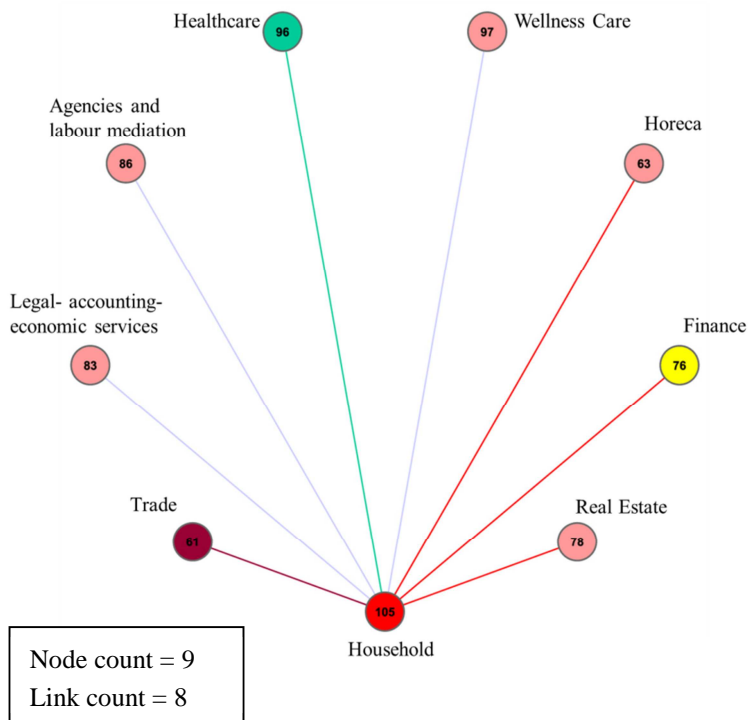
This plot shows the link weights greater than or equal to 1 billion euro. In this range remain 65 nodes and 131 links. The ranking shows Household as the most connected node, then we see node 61 of the Trade activity cluster node second, node 75 of Finance sector the third, node 50 of Energy the fourth and Telecom the fifth positions in degree ranking for large transactions.



**Figure 19: Money transaction network 2007 (link weight  $\geq 1000$  mln)**

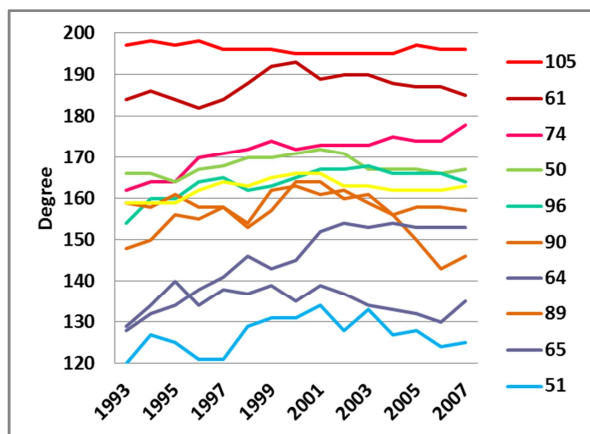
**Link weight  $\geq 10$  billion €**

This plot shows the largest link weights (greater than or equal to 10 billion euro) between activity clusters, whereby nine nodes and 8 links left over, from which 4 are the nodes corresponding to vital sectors (Household, Healthcare, Trade and Finance). Furthermore, nodes corresponding to non-vital activity clusters are identified, which are: Wellness Care, Agencies and labour mediation, Legal- accounting- economic services, Real estate, Horeca. Note that the household is connected with all the remaining activity cluster nodes but the other eight are not connected at all.

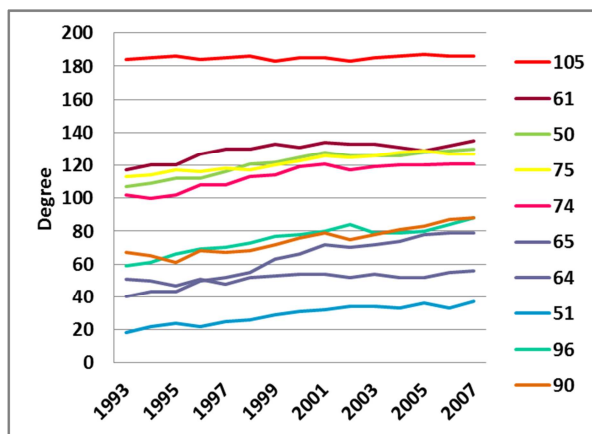


**Figure 20: Money transaction network 2007 (link weight  $\geq 10000$  mln)**

The Figures 16-20 above show five ranges of monetary networks derived from the I/O table for the year 2007. These networks are also plotted for I/O table data set of 1993-2006, and the results are combined in an animation. The set of four smallest ranges of these plots for the period of 1993-2007 is shown below.



**Figure 21: Degree of link weight  $\geq 1$  mln**



**Figure 22: Degree of links  $\geq 10$  mln**

Figure 21 shows the degree diagram of link weights greater than or equal to 1 million euro. We see a lot of fluctuation in all of the activity clusters. Figure 22 shows the degree diagram of link weights greater than or equal to 10 million euro, we see here that three clusters arise “Household”, “Trade, Finance, Energy and Telecom” and “Government, Healthcare, Transport and Water”.

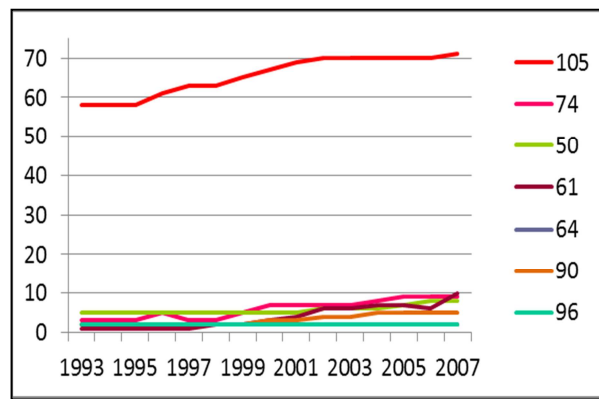
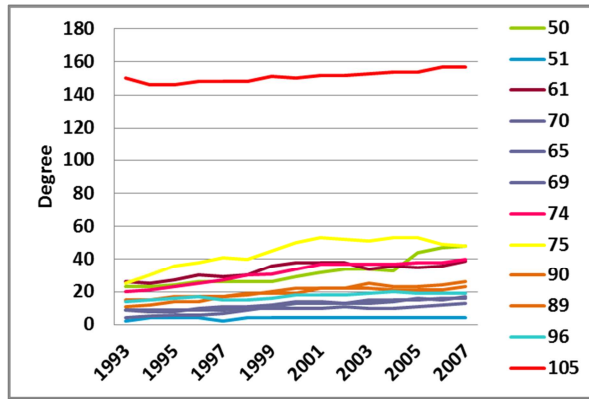


Figure 23: Degree of link weight  $\geq 100$  mln

Figure 24: Degree of link weight  $\geq 1000$  mln

Figure 23 shows the degree diagram of link weights greater than or equal to 100 million euro, here we see a huge separation of “Household” activity cluster from the rest of vital activity clusters. Which means that “Household” is most densely connected activity clusters for high amount of monetary transactions. Figure 23 shows the degree diagram of link weights greater than or equal to 1 billion euro, here we see that Household sector is at the highest connected and have an uptrend, while other vital activity clusters are further pushed to the bottom.

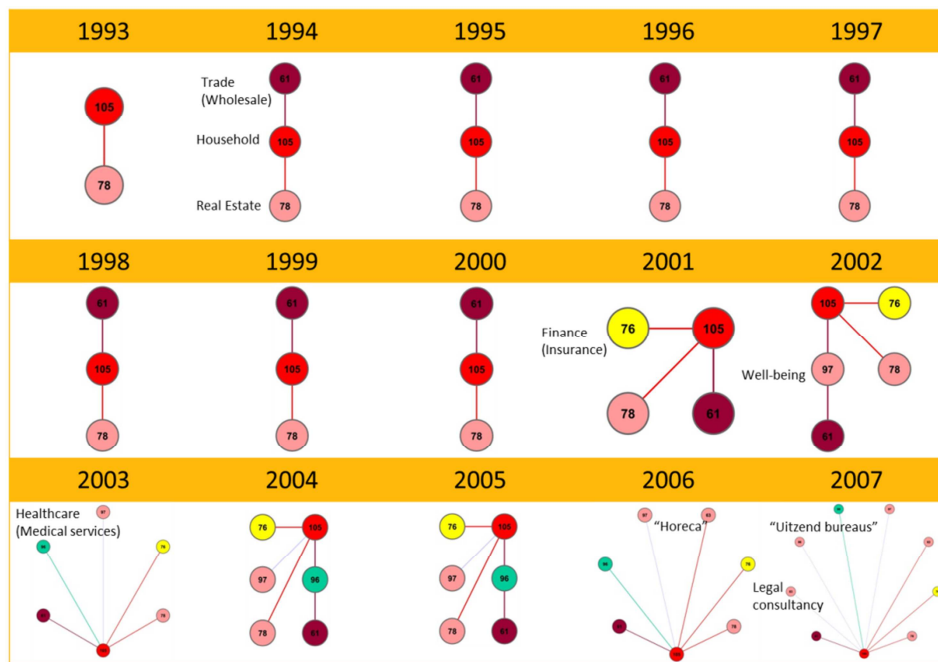
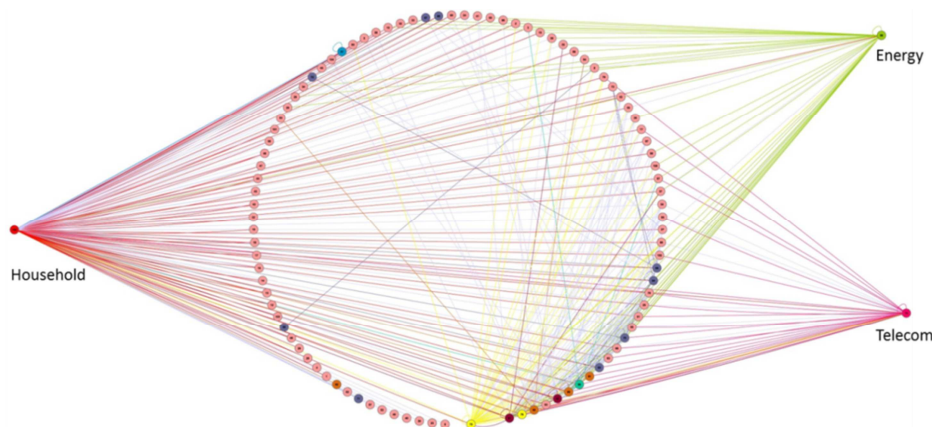


Figure 25: I/O Network link weight  $\geq 10000$  mln

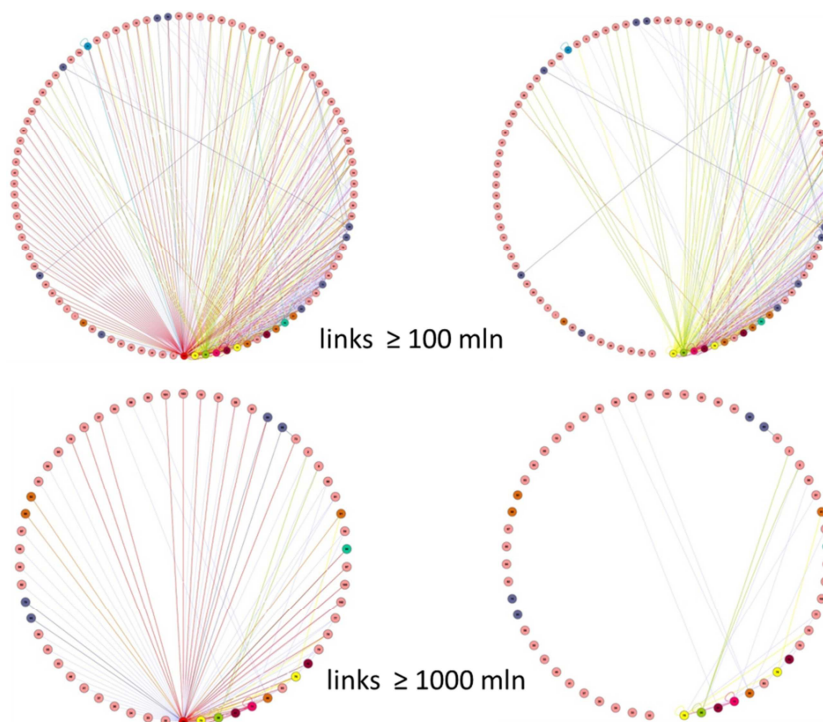
Figure 29 shows the I/O networks of link weight greater than or equal to 1 billion euro. It shows that it started with 2 nodes remaining in 1993 being the nodes 105 household and 78 Real Estate. From 1994 till 2000 there were 3 nodes in this range, with addition of the node 61 Trade (wholesale). Furthermore, from 2001 the network started to expand, whereby in 2007 like shown in Figure 19, nine nodes remain in this high range monetary network.

### 3.3.3 Ranking of the most dominant sectors



**Figure 26: Household, Energy and Telecom highly connected activity clusters**

The nodes corresponding to vital sectors have a higher degree compared to non-vital sectors  
 The three of the top 4 highest degree activity clusters are Energy, Telecom and Household.



**Figure 27: I/O Network 2007 without Household, Energy and Telecom**

Figure 27 shows two graph sets of the year 2007. The upper two graphs are corresponding to link weights  $\geq 100$  million euro and the lower two graphs represents link weights  $\geq 1000$  million euro. The node household is taken out from the graphs in the right hand side of each set. This shows how empty the I/O network became when there are no money transactions through household (node 105). There are only few links which go outside, those three sectors. It demonstrates that, when we take out the Household, Energy and Telecom (nodes 105, 50 and 74) then the graph has very low connectivity. This confirms the dominance of these three vital sector nodes. The difference in the number of links is significantly visible above 100 million euro. When the “household cone” is taken out of the network, we see a small minority of remaining links.

### 3.4 Conclusions from this chapter

The Dutch economic activities classification broadly follows, in aggregated level, the International Standard Industrial Classification of All Economic Activities (ISIC) classification system. The “Standaard Bedrijfsindeling, 2008” (SBI 2008) changed significantly compared to the SBI 1993. So it is clear that the SBI 2008 changed significantly compared to SBI 1993. The branching of the activity cluster trees in SBI 2008 is more homogeneous than in SBI 1993. The tree structure analysis of SBI 2008 reveals that section U “*Extraterritorial organisations and bodies*” do not show any branching out. This leads to the conclusion that section U is not a full-fledged section compared to all other sections in the classification system.

Both SBI 1993 and SBI 2008 define the household at the section level. From a historic perspective, the main reason for this choice is the fact that household production for own domestic use cannot be accounted for in any other section.

Looking at the number of working people in each section of the SBI 1993 during the period of 1993-2007, it is discovered that number of working people in the section D “*Manufacturing*” has most decreased. The reason for this could be the automation and outsourcing/offshoring of manufacturing activities. Furthermore, the number of working people has increased particularly in section K “*Rentals & real estate and business services*”, and specifically in the division 74 which corresponds to “Other business activities” of SBI 1993. More precisely, it corresponds to the group 745 “employment agencies”. The plots of the number of working people over the standard SBI 1993, shows a concentrated number of people in some of the activity clusters while other activity clusters have a small number of people. However, this effect is clearly visible when looking at the animation of the number of working people that resulted from the research.

The Dutch Ministry of Interior Affairs has identified 12 vital sectors of which only five are recognized as an ISIC section. The vital sectors are mapped on the SBI 2008 classification standard. The specific vital part of most recognized sectors proved out to be a small part of the corresponding activity cluster tree. So there are four parts of the Government sector which are qualified as a separate sector. In the vital sector set of the Ministry of Internal Affairs, “food” is qualified as a sector name. This is not commonly recognised in ISIC as section or division neither do classification experts agree on this choice.

All sectors both vital and non-vital mutually depend on each other. This dependency is reflected in their strongly interwoven infrastructure. By studying the relationships between the vital sectors, a vital sectors hierarchical graph is proposed. This hierarchical graph can also be used to show the monetary transaction delivery between the vital sectors.

Furthermore, to figure out the connectivity of the sectors, the monetary transactions between all sectors are represented as a network. Thereby the vital sectors are highlighted in these networks and, the focus is dedicated to the node weight property of the sectors. This helps to rank each sector in the range of connectedness. The results have shown that the vital sectors are actually the most connected nodes in these monetary networks. The four highest connected nodes are Energy, Telecom, Household and Finance. Moreover it is discovered that when removing the highly connected nodes from the network, it becomes nearly disconnected.

## 4.

# A trend analysis of a changing network, its vital sectors and hierarchy

---

*This chapter discusses the main observations derived from the SN data sets and the expert interviews to derive the most important trends around Telecom, Energy and Household. The households are increasingly shifting from consumers to “prosumers” and provide services to other sectors. Furthermore, we observed that ICT is an essential enabler for service delivery to and from the house. So the Telecom being the essential part of the information communication sector is an important enabler of these trans-sector innovations. The integration of ICT in the Energy sector is one of the examples. It is becoming an increasingly interesting topic, governments and large numbers of enterprises are investing a lot of money in sustainability of the energy and its usage.*

### 4.1 Monetary trends

Based on the SN data sets as discussed in chapter 3, this paragraph analyses the monetary trends in the Dutch sector network in the period 1987 – 2007. This monetary trend analysis was performed as a specific task for internal use within KPN to derive guidance for new business developments.

The monetary trends were plotted as a graph diagram both in absolute terms (corrected for inflation) and in the normalised form for diverse views of the 9 vital sectors. In addition, for each specific view also the percentile distributions are shown for the 3 selected years 1987, 2000 and 2007, respectively.

For this MSc thesis, the monetary trends of the 9 vital sectors for the views “total household spending” and “total production” are explained hereafter in more detail.

Below a stacked diagram is given that shows the increase of yearly monetary transactions at the sector level. Appendix B contains the activity clusters and a mapping at the superior sector level.

#### 4.1.1 Total household spending in Netherlands

Figure 28 provides the monetary trends of the nine selected sectors in the context of total household spending in the period 1987 - 2007.



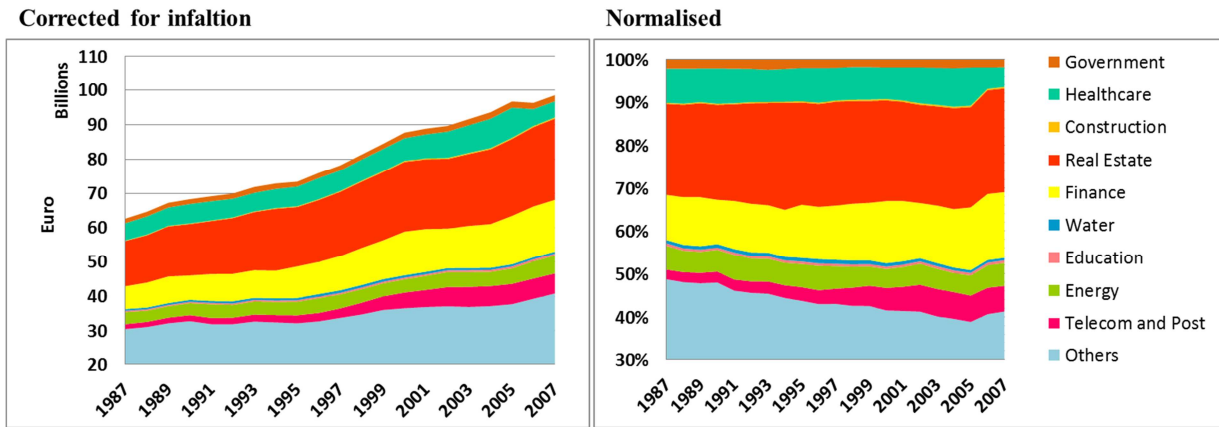


Figure 28: Total household spending in absolute terms and in normalised form

### 4.1.2 Production sector network

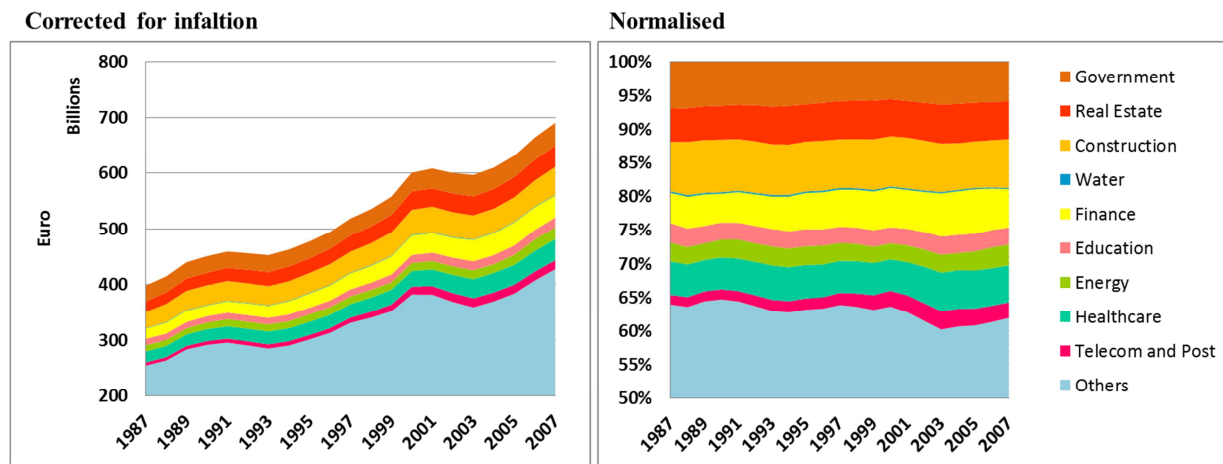
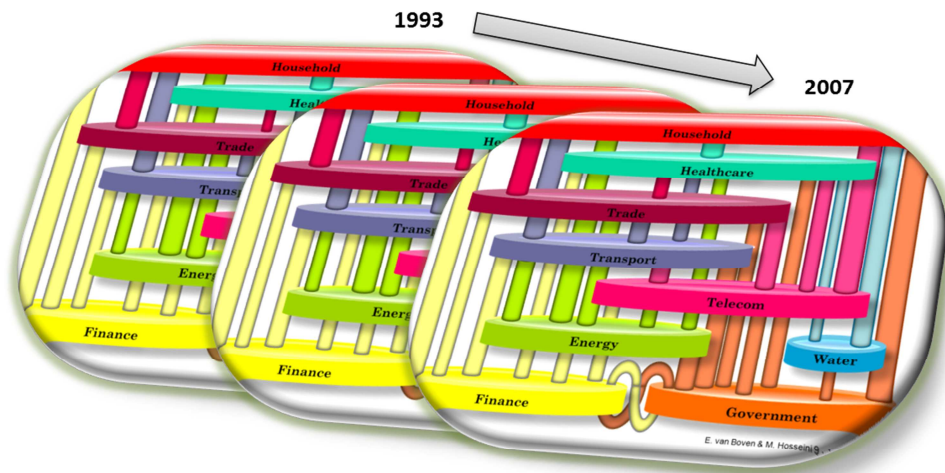


Figure 29: Total production in absolute terms and in normalised form

Figure 29 shows the stacked diagram of total production in absolute terms and in the normalised form for a selected sector list. In Figure 29 the education sector production is not included. The Input Output table of SN National Accounts books the education sector production as being consumed by the government. Furthermore, the construction sector production is partly booked (approximately 1/3), because the other 2/3 is booked as investment.

## 4.2 Monetary analysis of the vital sectors



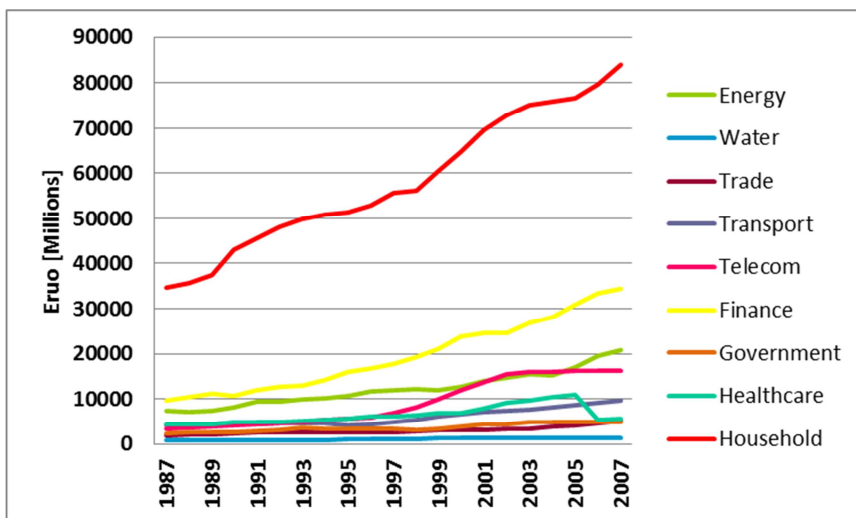
**Figure 30: Monetary dependencies of vital sectors (1993-2007)**

Figure 30 illustrates the hierarchical graph introduced in section 3.2.31. This hierarchical graph can be used to show the monetary dependencies of the vital sectors. The pillars thickness corresponds to the relative amount of money transacted between adjacent nodes. However, this is an illustrative representation of the monetary dependencies. In this paragraph, the monetary analysis related to the vital sectors is accomplished based on I/O table.

### 4.2.1 Total monetary transactions of the vital sectors

Following are some results from data mining in I/O table of 21 years (1987-2007), corresponding to total money transactions toward, from and within each vital sector.

#### Incoming euro flows



**Figure 31: Incoming euro flows**

Figure 31 shows the incoming euro flows of each vital sector. This diagram shows that the household's incomes are the largest of all vital sectors, which corresponds to the salaries of working people, followed by the incoming monetary transactions of Finance, Energy and Telecom.

### Internal euro flows

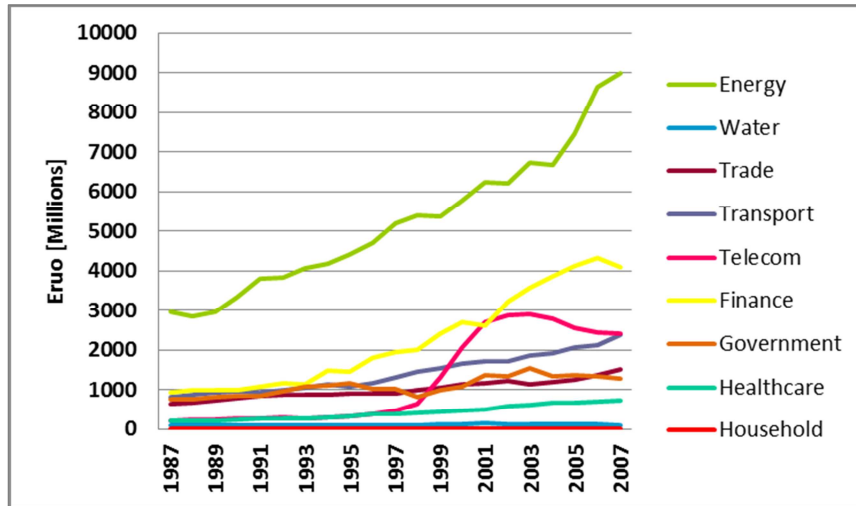


Figure 32: Internal euro flows

Figure 32 shows the internal euro flows of the vital sectors. At first glance we see that the Energy sector has the largest internal euro flows, followed by the Finance and Telecom sector. The slope of Energy internal flows is the steepest from all sectors, and in the years 2005 to 2007 it has the strongest slope reflecting the creation of separate units for separate activities like distribution, trade and maintenance. Furthermore, it can be observed that the Household sector has a nearly zero internal euro flow. This is because within the Household sector, there is nearly no economical relation between the households. By definition, if a household performs paid services for other households this household is considered an enterprise and will be part of the sector which corresponds with its activity, for instance agriculture or trade. Currently, the household sector is only a customer of other sectors. It doesn't provide value to other sectors.

### Outgoing euro flows

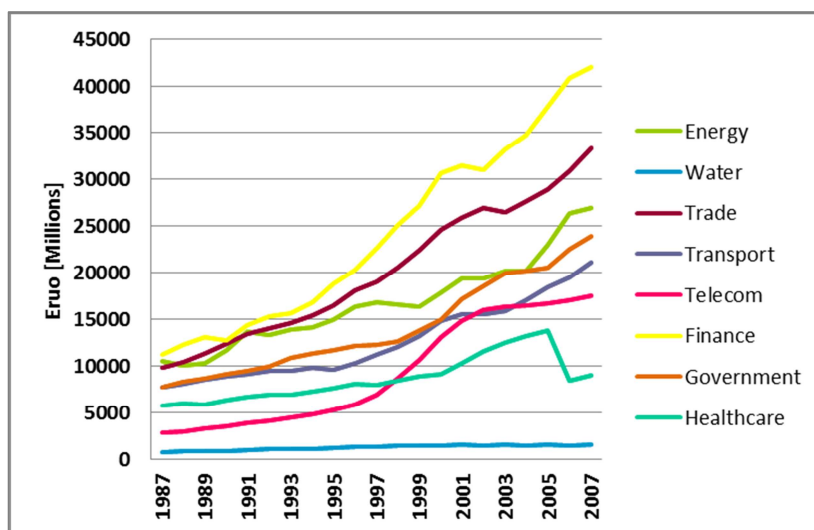
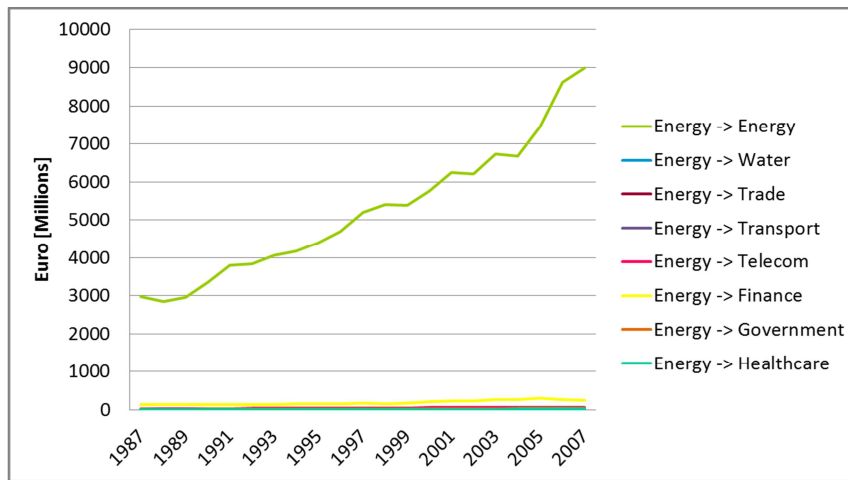


Figure 33: Outgoing euro flows

Figure 33 shows the outgoing euro flows from all vital sectors. Finance, Trade, Energy, Government and Transport have respectively the fastest growth in transacting money to other sectors. However, Telecom sector had a fast growth from 1997-2001, and after that it arrived in a saturation phase. Healthcare sector shows a strange trend break in 2005-2006. This has to do with a change in settlement of insurance expenses, which will be explained below Figure 38.

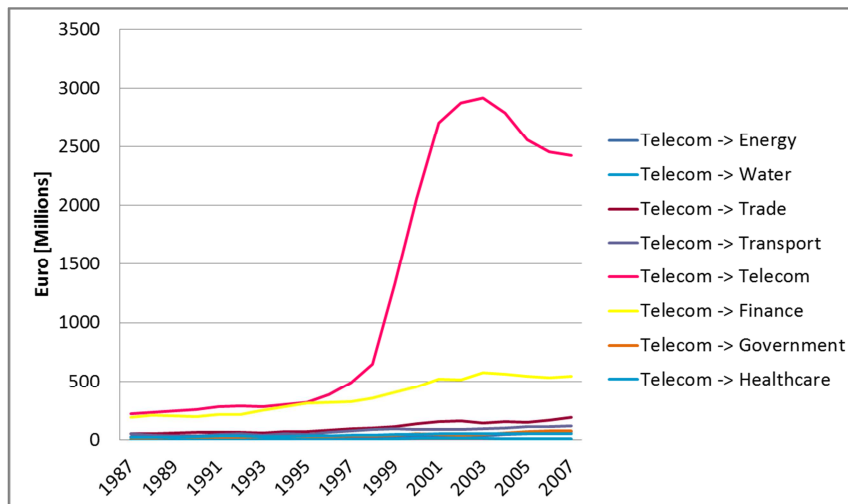
#### 4.2.2 Monetary transactions between the vital sectors

Following are some results from data mining in I/O table of 21 years money transactions between the vital sectors. From all vital sectors, a diagram of outgoing euro flows is created using Matlab and Microsoft Excel. Only a subset of the diagrams, which provide interesting information, is captured in this section, the complete set can be found in appendix C.2.



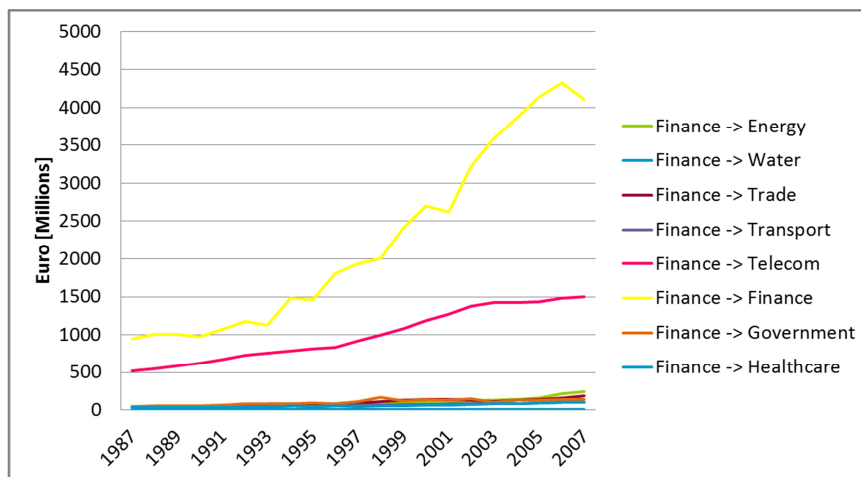
**Figure 34: Outgoing euro flows from the Energy to other vital sectors**

Figure 34 shows the outgoing euro flows from the Energy sector to other vital sectors. However, it is not only outgoing flows, but also the internal flows are showed, e.g. Energy to Energy. Furthermore, Figure 34 shows that the largest amount of transaction from Energy sector is transacted to itself, and it has a very fast growth. This can be explained as investment costs of Energy sector to itself. Think of investments in sustainability of energy infrastructure. Besides, note that the transport of energy belongs to the Energy sector, not to the Transport sector.



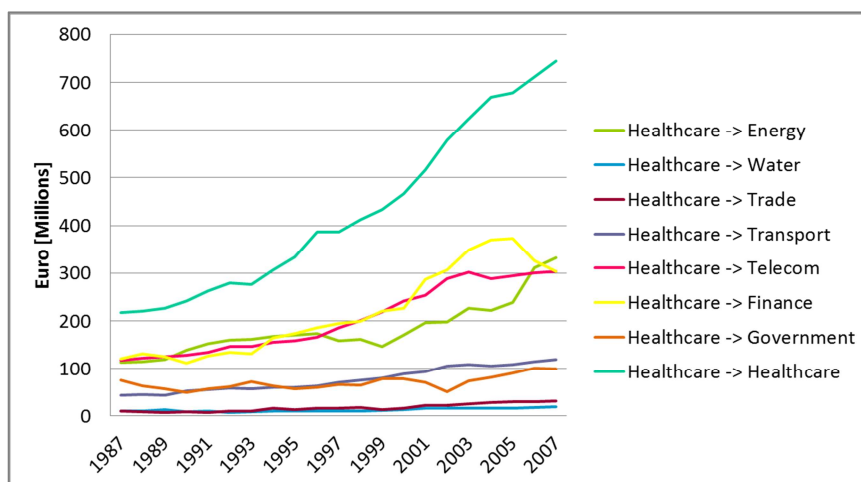
**Figure 35: Outgoing euro flows from the Telecom to other vital sectors**

Figure 35 shows the outgoing euro flows from the Telecom to other vital sectors. This diagram shows the extreme growth in internal expenses of Telecom sector during 1998-2001 and followed by retrieval in 2001-2007, which is also referred as the crash of internet bubble. Typical of that period was the rapid establishment and sometimes even unexpected rapid demise of numerous Internet companies, the so called dot-com (.com) companies. A combination of rapidly rising stock prices, massive stock market speculation by individuals and readily available investment capital has created a euphoric mood, whereby the longstanding trust of shareholders decreased dramatically. When the bubble in 2001 was caused, it snapped an unexpectedly prolonged global recession which was mild in most Western countries.



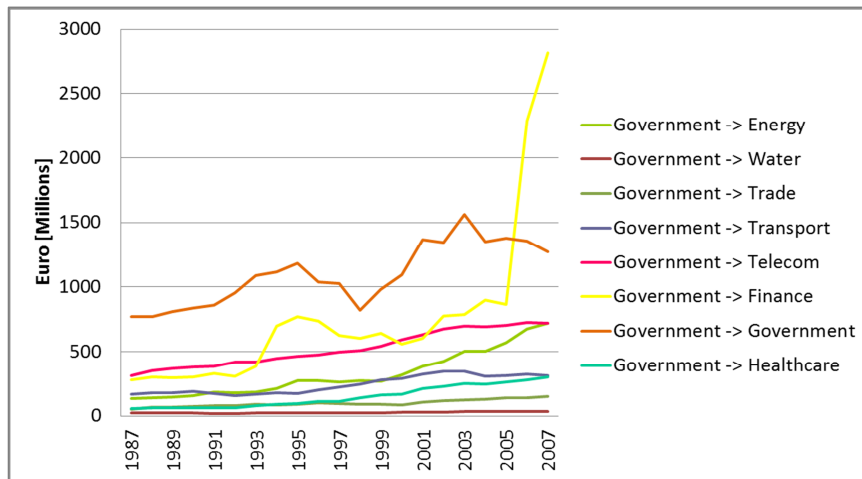
**Figure 36: Outgoing euro flows from the Finance to other vital sectors**

Figure 36 shows the outgoing euro flows from the Finance sector to all vital sectors (including itself). The diagram shows that internal expending's of the Finance sector is the largest among expending's to other vital sectors. Furthermore, the outgoing euro flows toward the Telecom sector is also strikingly more than toward other sectors. This shows how the finance sector is dependent from the telecom sector.



**Figure 37: Outgoing euro flows from the Healthcare to other vital sectors**

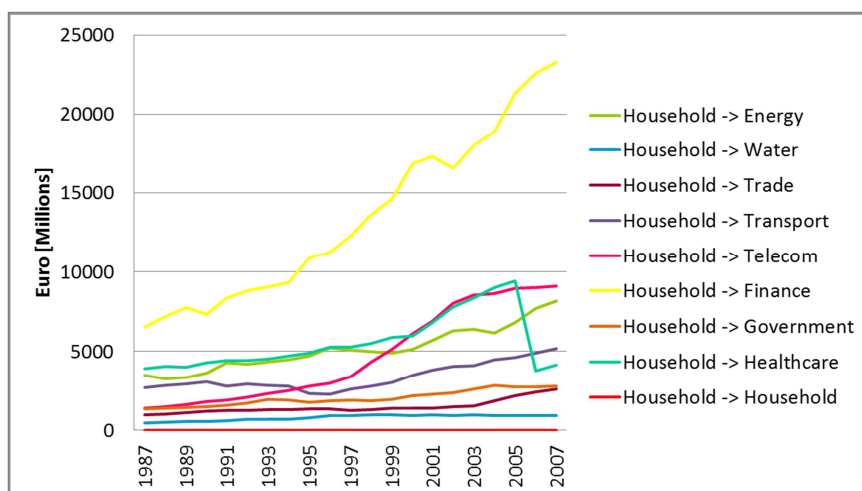
Figure 37 shows the outgoing euro flows from the Healthcare sector to all vital sectors (including itself). Again the internal euro flow of the sector itself is the largest of all outgoing. However outgoing euro flows of the Healthcare sector, has a larger fraction of spending to other vital sectors, which suggests this sector is more like consumer of other vital sectors.



**Figure 38: Outgoing euro flows from the Government to other vital sectors**

Figure 38 shows the outgoing euro flows from the Government sector to all vital sectors (including itself). The diagram shows an unexpected<sup>11</sup> trend break, when looking at Government expending's to Finance sector in the period 2005-2006. On January 1, 2006 the Dutch health insurance entered into the new health system. This has significantly changed the health insurance in the Netherlands. The sick funding law (ZFW) is replaced by the health insurance law (ZVW) and the distinction between compulsory and private insurance has lapsed. Instead, the new basic insurance is introduced which is compulsory, for everyone living in the Netherlands or below the payroll tax falls [14].

The monthly figures on household consumption are consistent with the concepts and definitions of National Accounts. Since the new health insurance is mandatory, according to the international guidelines for compiling national accounts, these are included in government consumption. All expenditure on medical care of previously privately insured, provided the basic package now included in 2006 are therefore, not accounted as household consumption. Supplementary insurance for care not included in the basic package, is regarded as household consumption. Thus the introduction of the new healthcare system in the national accounts leads to a shift of the consumer spending by households to the consumption by the Government.

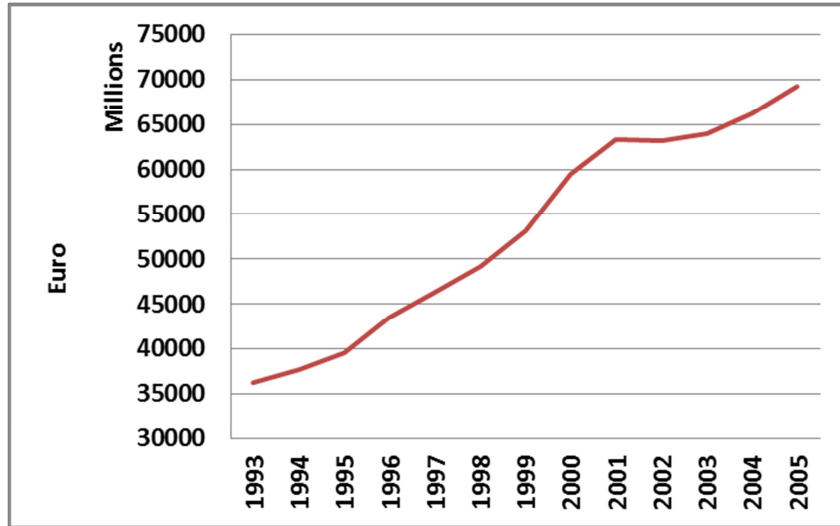


**Figure 39: Household spending's to other vital sectors**

<sup>11</sup> An explanatory research is on-going in cooperation with Statistics Netherlands.

Figure 39 shows the outgoing euro flows from the Household to all vital sectors (including itself). The household spending to itself is nearly zero, like explained in 4.2.1 (below Figure 32). In Figure 39 we see that, because of the transfer of a large proportion of care for Government consumption, consumption by Households to Healthcare is in 2006 much lower than in previous years.

### 4.2.3 Trend comparison I/O table and WP for the vital sectors

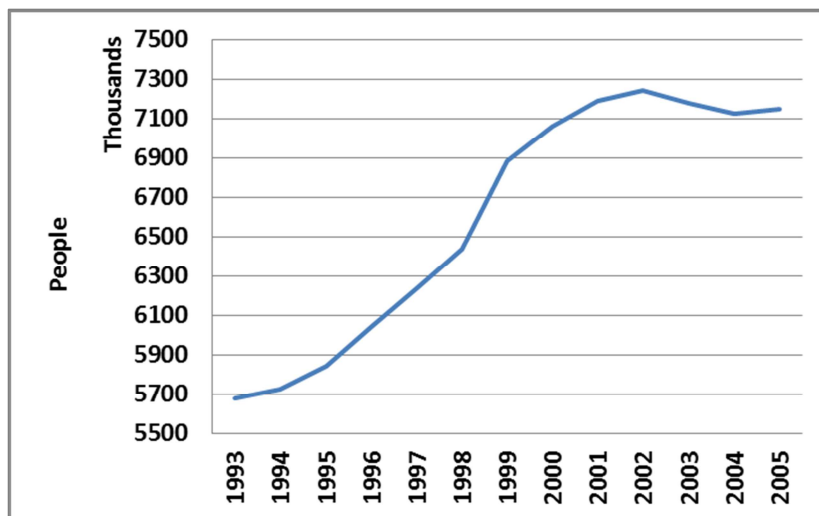


**Figure 40: Sum of all diagonal elements of the I/O table (1993-2005)**

Figure 40 shows the total diagonal elements (node weights) of the I/O table from 1993 to 2005.

#### Node weight of the sectors

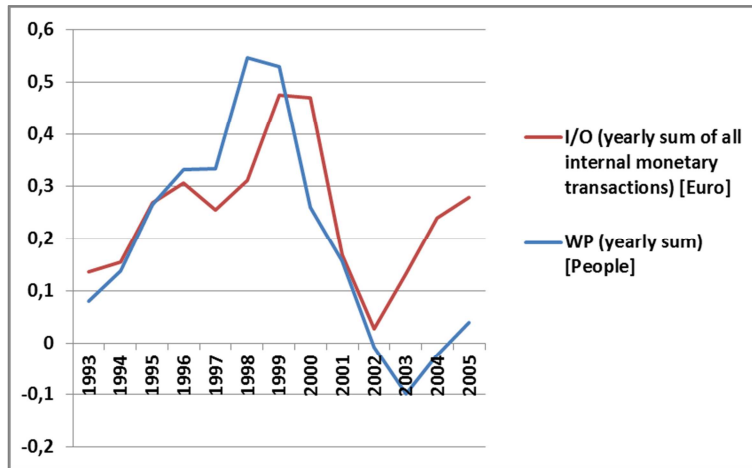
The diagram of Figure 40 shows the total amount of money staying in all the sectors and Figure 41 shows the total working people in all sectors (1993-2005). The first observation we achieve by comparing these two graphs is that both working people and money in the sectors have an uptrend in the period of 1993-2001. After this period, there is an offset in the amount of money, but it takes again the uptrend at 2003, whereby the working people take off. It can be argued that in the period of 2001-2003 people are fired by the organisations to compensate the reduction of internal value.



**Figure 41: Working People (1993-2005)**

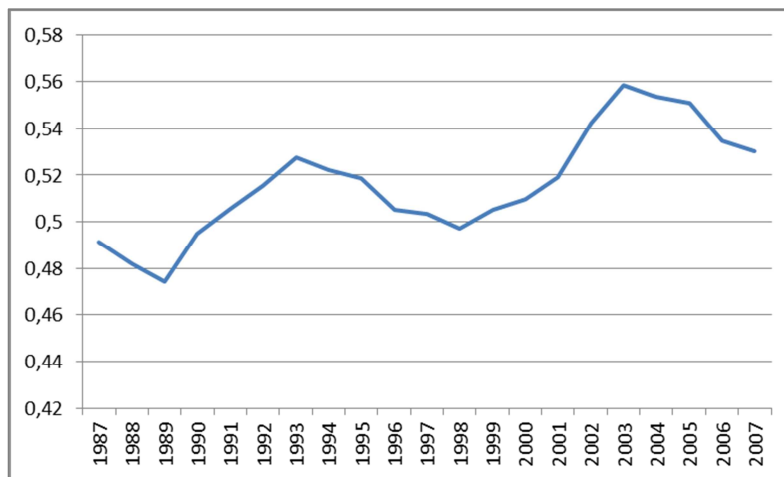
### Comparing the trend of WP and I/O (diagonal elements)

Our I/O table derived matrix from of 105 by 105 (see subparagraph 3.2.2), whereby the diagonal elements are the node weight values of each sector. So these diagonal elements give us a vector of length 105 for each year, we sum up the diagonal elements corresponding to the period 1993-2005, which gives us a vector with length of 13. Then we take the gradient of this vector and normalize it using Matlab. The same procedure is done for WP dataset gradient of the yearly sum is normalized for the period 1993-2005.



**Figure 42: Gradient comparison of WP & I/O (diagonal elements)**

Figure 42 shows the plot of the normalized gradient of WP (yearly sum) and I/O (yearly sum of all internal monetary transactions). We see that in the period 1993-2000 both curves show an uptrend which means the number of working people and internal monetary transactions were growing in this period. After the crash of internet bubble in period 2000-2002 they both have downtrend, but yet the number of working people goes further downwards until 2003 and then there comes an uptrend. The two curves show a parallel spaced upward trend. The reason for this space in the trend could be that companies fired employees to cut costs and one year after the crash (2003) slowly started to hire new employees.



**Figure 43: Ratio vital sectors divided by total sector network euro flows**

Figure 43 shows the ratio of vital sector outgoing euro flows divided by total outgoing euro flows. This figure illustrates that in general the vital part of the sector network euro transactions is increasing if we look in the long term scope. Furthermore there are two significant peaks at the year 1993 and 2001. Obviously the second one represents the crash of internet bubble.



## 4.3 Smart Living service bundle

### 4.3.1 Analysing the future needs for Smart Living

#### Development of communication infrastructure

The time when you had to pay for media in hardcopy form (e.g. a CD or DVD) is nearly behind us. Through the Internet, content is available on demand. Currently, the Internet business has still gaps regarding to the ownership of content. However, the traditional suppliers have no business model yet, by which money can be earned. And customers should get used again to the idea of “paying for usage”. Publishers will need to transform into Rental Company of intellectual property.

The Netherlands have an excellent communication infrastructure. In comparison to other countries also in near future, The Netherlands still has a compliant communication infrastructure. It is expected that this communication infrastructure will consist of a nationwide fibre optic network to every home soon. The positive developments in The Netherlands broadband explained due to the presence of all the success factors for a good broadband penetration. The excellent telecommunications infrastructure in The Netherlands is very interesting for a large number of international service providers to take profit from the densely populated Netherlands as an easily accessible and highly available launching market.

A government intervention in financial investment in infrastructure is not needed according to a market survey published by Deloitte [15]. It is expected, that more fibres will be rolled out in DSL networks and that cable providers will have the potential to facilitate their networks with Hybrid Fibre Coaxial (HFC), which already consists of 97% fibre. Furthermore, mobile networks will continue to exploit their resources and increasingly spread to broadband (e.g. by LTE). Thus the supply of broadband is sufficient enough to meet the demand for the coming years.

#### Smart Living service bundle

It is important for a telecom operator like KPN to anticipate on expected developments in the entire sector network. Therefore, a forecast of conceptual developments is necessary. An understanding of the trends related to these developments will help the service and network providers to bundle these sector related services. A service bundle can be defined as various levels of functional-content based on customer/individual user's needs. The Smart Living service bundle needs to offer the possibility that finally many sector specific services will be affordable, but also new trans-sector services may arise (e.g. integral energy management of the house, trans-sector billing, etc.). From a technical perspective, it comes down to the next rollover in the network. It is important that resources such as fibre optics, cameras and sensors not seen as sector specific, but purely as functions that serves all sectors. Not only technically, this means a tilt of the current structure, but also in the thinking and completing business cases.

### 4.3.2 Methodology

At the beginning of the thesis research, it was assumed that a service bundle would be provided by a Smart Living team consisting of co-workers of the KPN NL segment consumer, segment business and TNO. The Smart Living service bundle which was needed for this graduation project, in order to determine the impact on the current telecom network, was not delivered in the agreed time period. Professor Nico Baken invited us to spend some effort on this subject. The Smart Living service bundle describes the main future service concepts that KPN could provide to other sectors. We tried to make an inventory of the most obvious future communication related concepts involving Energy, Household, Transport, Trade and Healthcare. Then we discussed all of these concepts with innovation experts from KPN, to explore the importance of these concepts in the year 2000, 2010 and to forecast the expectation for the year 2020. Appendix C.3 covers the outcome of the interviews. The distinguished innovation experts listed below participated in the interviews:

- Ad Bresser
- Colin Pons
- Franklin Selgert
- Peter Maarten Westerhout
- Dr. Ramin Hekmat
- Sander Tolsma

### 4.3.3 Results from the expert interviews

About 60% of people in the world who have access to the Internet are everyday online. Already, the daily use of TV, radio and newspapers, remains well behind. The Dutch online consumer is a major consumer of media. Nearly 70% of them are online daily. The e-mail traffic is slowing and social networks are booming and mobile Internet is becoming increasingly popular. People with mobile internet on their phones do seem very addictive. Those who have mobile Internet, spend an average of 3.1 hours per day to their social networks and 2.2 hours to e-mail via mobile phone. This is evident from a study by global research company TNS NIPO. The general trend observed from all interviews is that new concepts are added but hardly any old ones disappear. Below some highlights of the expert interviews related to the concepts of Table 14 (appendix) is described.

#### Message from A to B

In the past, chatting was often based on a separate engine, but in the future there will be a more generic chat service. So the user will be able to chat across all things they are performing over the internet. An SMS is mostly used to send a short text message, this trend is probably going to expand itself more as generic short messaging concept. Moreover, the SMS and internet chat will become more interoperable. *(Peter Maarten Westerhout)*

There are various types of contexts messaging e.g. Email, SMS, Video, attachments and voicemail which often referred as human-to-human communication. There are also other types of messaging where human interaction is not included, which is also referred as machine-to-machine (M2M) communication. Currently M2M communication is often about status information exchange. There are few websites such as Gowalla.com, Foursquare.com, Google.com/latitude using location status of mobile users to locate their social community and also provide other useful information around them. *(Colin Pons)*

Another form of communication is messaging where no voice or video is involved but for example the colour or light exposure. So when the resident gets home the lights are changed to a certain colour, e.g. light is soft when someone is watching TV. This is also called “Ambient Messaging”, and probably this trend will take off inside houses and around residents. It may be that phone is blue lightened when a

specific person is calling. So the user will get information, not only by text and voice but also by colour or lightning. *(Peter Maarten Westerhout)*

### **Content distribution**

In terms of content sharing, there are many peer-to-peer (P2P) content distribution networks which were started in the previous millennium. A P2P network is a network of different computers connected around the world. Examples are Kazaa and Gnutella and many more. These kinds of networks will still exist in 2020. Because P2P is one of the most effective ways to distribute content and it is particularly efficient. The P2P is about the content distribution, it requires a high security of the content, to become confidential for industry usage. Currently, it is possible to download an encrypted content, whereby you need to pay for the key to decrypt. This form of distribution is also proposed for electronic patient record distribution (“Elektronisch patiëntendossier”). Whereby, the patient’s healthcare related data will be available for the hospital, general practitioner and other qualified people. According to their function they will get access to some part of the data. For this purpose P2P distribution will be very efficient, but the content security will be very important to protect the personal data of the patient, with several security mechanisms and different user groups. Formerly, the World Wide Web can be used for this purpose, and there is no need to use a separate intranet for this purpose. The Internet is a vast distribution network, which is available almost everywhere. So when the rest of the shield as close as possible to bring the content and other features too into it, you can also easily distribute content and the proper shielding, the right function to each user identified. Now this form of content distribution is not widely used. By bringing the security shield closer to the content itself, the distribution of the content will be more easily using efficient P2P distribution models. *(Ad Bresser)*

### **Personal content**

In the past there used to be a paper photo album, but with the advent of digital cameras, currently, there are mainly digital photo albums available. Community and personal video collection are already in use, in the future there will be a lot of privacy issues around it. The same goes for content generation, so everyone will have its own content delivery. Artificial Intelligent (AI) will boost up the content generation. Image recognition technics extensively used with AI, will make searching much easier, and easily place the content in a context. An application needs only three things: Communication, Storage and Processing. If there is processing capacity, then an application can be executed. Furthermore, if there is storage capacity, an application can store things and can bridge in time. Finally, if there are communications resources, applications can communicate with each other or with humans. If these three resources are available, basically all the functions and requirements performed. *(Sander Tolsma)*

### **Security in Payment**

In the future the mobile payment will largely grow, but also the social currency emerges. For example, Google has officially announced that they have acquired the Social Gold virtual currency platform. The platform provides an ecosystem for transactions in virtual currencies, facilitates purchases in virtual worlds, video games and social networks. The technology allows developers to integrate payment systems into games and competes with similar payment systems such as Facebook’s credits. Social gaming is very hot right now. It seems that barely a week goes by without another acquisition of a social gaming firm, often for large amounts of money. *(Peter Maarten Westerhout)*

### **Presence**

Right now, the coincidence of high-definition, immersive videoconferencing and high fuel prices have many people excited about the potential for substituting tele-presence for travel. Furthermore, Social networks are getting more and more popular. The user finds his or her peers and exchange knowledge and experiences with them. Customer testimonials about product and services go with the speed of light through the social network. Currently, there are many social networking parties in the market, e.g.

MySpace, LinkedIn, MySpace, Twitter, Flickr, Ebay, Facebook, YouTube, Google Video, Gmail.  
(Franklin Selgert)

### **Internet of things**

One of the buzz-words that you often hear when talking about future technological models is the “Internet of things”, the sharing of useful information, not only among humans but also subject and object. For example, your refrigerator will be able to talk to you, something you probably never believed in the past. The internet of things involves a lot of “Machine to Machine” (M2M) communications. The telecom market for M2M is potentially much larger than for communication between people, because the number of devices is much larger than the number of people. Although, there are already many devices unobtrusively “online”, but the financial barriers to make machines communicative is too high for most companies. A few service providers and suppliers present the “M2M community” that brings M2M as an accessible service in the market. However, M2M is still in its starting phase. (Dr. Ramin Hekmat)

### **Packaging**

Many new services are a combination of few basic services, and in the future these essential services will remain. It will not be like current services combined with a lot of other services combined with them. Considering the mentioned expectation that services will go back to their basic form, there will be parties who package these services in a certain way. In the telecom world, we have a model called “Packager”, and there are already many providers using it. The huge amount of combinations it is not clearly comprehensible for users themselves, to package their own services. So they will need someone to compose a package for them. However, there will always be some people who want to do certain things themselves. However, the service providers will provide a basic package which has, let’s say 80% of all and an additional package which also contains the remaining 20%. This applies to all the concepts of Table 14. (Sander Tolsma)

### **4.3.4 Impact on the telecom network**

Entrepreneurs of today do not want to think about changing servers, routers, switches and firewalls, but want business data safe and cost effectively manage their infrastructure, regardless of the size of the organization. The ICT manager is better off with a managed IP VPN. The rise of distributed ICT and virtualization of desktops and servers is unstoppable. The physical location where business applications are housed is no longer the same as where users are located. Also, accessibility requirements, as currently needed to be allowed in an ICT environment, are much tougher. Information and applications have 'anytime, anywhere and on any device "can be approached, but it must be secure and confidential. As the industry continues to grow, the communication and information applications also continue to grow, both in terms of traffic and requirements on the network. These should be faster, higher bandwidth, must have a maximum uptime and preferably redundant. This calls for a new ICT landscape, which has to include mobility, workplace independence, integration of voice and data and standardized modern operating systems. From the results of the interviews the impact of the service bundle on the telecom network can be derived. The following are the most important points impacted by the needs of the service bundle:

- Identity management,
- Security,
- Content processing,
- Storage,
- Smart Pipe (dynamic bandwidth management),
- SLA,
- Application Enablement, Third party interfaces,
- Next gen communications services , e.g. high quality end to end video communications
- Fixed mobile convergence, complementary access
- Location based services

The results of the analysis in this MSc thesis points to a number of issues for further action that may help KPN to refine the foreseen potentials within the service bundle and the identification of concrete initiatives for the successful realisation of new business services. These new business initiatives refer to partnerships with energy companies, healthcare institutes and other trans-sector leads to strengthen KPN involvement in services around the house and the daily live. The following follow-up actions are suggested:

1. A deep dive analysis of the extensive expert interview material gathered as part of this MSc thesis possibly enhanced with further expert interviews and desk top research.
2. To make a correlation between the results of the sector analysis in chapter 3 with the service bundle items to prepare a roadmap for new business initiatives for and with other sectors.
3. Further exploration of the discrepancy between the increasing role of telecom as vital sector versus the decreasing revenues from traditional telecom services that asks for a revitalisation of the telecom sector form the business model perspective and its role in the society.
4. To pay special attention to the consumer demands around the house and the daily live as this MSc thesis has shown clear evidences that the household is very dominant vital sector that is most connected with other sectors wherein telecom plays an increasing role as enabler.

## **4.4 Role of ICT in society**

ICT measures are important tools for innovation. Therefore, ICT can be an effective instrument for many society needs and issues. Think of the use of ICT in location independent working. If more people work from home and keep in touch by mail and webcam, it will save a lot of traffic jams. Intelligent services and products can regulate and dynamically control the household's energy consumption, such as turning off devices when you leave your home or office. Virtual solutions can replace physical products and services, such as invoices by mail.

### **4.4.1 Healthcare**

One way to improve the quality of life is by making the home environment a more comfortable place to live in by turning it into a Smart Home environment. Healthcare at home helps to reduce the operational pressure on hospitals, e.g. patients can be under control at home without having to stay few days in the hospital, or they don't have to visit the doctor for every illness. Furthermore, it helps aged people to be aware of their health and be under control of a care institute. With this innovation not only economic efficiency will be realised but also the healthcare will be efficiently used, and it will be one step toward a healthier world.

Within healthcare, the main challenge for ICT research is to develop systems that alleviate the pressure on the caregivers without compromising the quality of care. The same amount of work should simply be done with fewer people. An important aspect here is the housing. The trend is that more people will stay in their own homes and less likely be placed in a nursing home. In order to ensure this, the home should be smarter: namely, it should take over certain tasks of the healthcare providers. Of course not every task can be taken over and implementation of a robot that can help the user to take a shower will take time.

The solution is close to the home and yet by using the Internet. By supporting elderly with ICT in their district or neighbourhood, it gives them more opportunities and confidence to live longer independently in their home and participate in social life, with or without support.

Telecare is a term given to remote care for elderly and vulnerable people, providing the care and reassurance needed to allow them to remain living in their own homes. The use of sensors may be part of a package which can provide support for people with illnesses such as dementia, or elderly people. Telecare by nature is reactive, not preventive, as it will not prevent, e.g. falls or floods but can allow others to react to their occurrence. Telecare is specifically different from telemedicine and telehealth. Telecare refers to the idea of enabling people to remain independent in their own homes by providing person-centred reactive technologies to support the individual or their care givers [52].

In its simplest form, it can refer to a fixed or mobile telephone contact to monitor or to inform of any development. A technologically more advanced solution is through the use of sensors, wherein a range of potential risk situations including wandering (particularly useful for people with cognitive impairment), falls, as well as environmental issues such as floods, fire and gas leaks. When a sensor is activated it sends a radio signal to a central home unit, which then automatically calls a 24-hour monitoring centre where highly trained operators can take the most appropriate action, whether it is contacting a local key holder, doctor or the emergency services.

#### **4.4.2 Energy**

If we look at existing stove-pipes (e.g. metering), and knowing that a part of Smart Grid concept is closely related to this, what kind of innovation would be valid for this enhancement?

If we consider that the current metering will be a part of the future Smart Grid concept both the architecture and components must be enhanced.

- Architectural: there might be new servers needed to store the data from all customers, this may need an efficient hierarchical structure.
- Component: the metering data may contain larger volume, (is a wireless connection still a good choice?) the enhancement to fixed network usage, metering data must be available for other parties, e.g. Electricity providers.

Smart Grids help power producing companies to manage their entire electricity system as an integrated framework. To sense and respond to changes in power demand, supply and costs to improve the reliability of energy delivery and optimize operational costs. A comprehensive view of the grid status is becoming increasingly important, particularly with the need to incorporate a broader mix of renewable and low carbon energy generation sources. The increasing complexity of managing the system efficiently requires intelligent infrastructures, to optimize grid management and significantly reduce outages. To do this, all elements supply sources, the grid and customers must be able to interact with each other.

Currently there are over 360 proprietary communication protocols used in the electrical system, making it impossible for different systems to operate with one another. To enable this communication all of those elements must converge on an open platform and an internet protocol communications network. Better information will also help customers manage their energy usage, to meet their personal needs. It will reduce the amount of energy consumed by homes and significantly reduce peak period demand. To achieve this, customers need to adjust their equipment, washing machine, dishwasher, boiler, swimming pool water-pump to use low cost electricity during off peak periods. The consumer simply loads and starts the dishwasher as usual, the only difference is that the machine will provide the option to start when the electricity costs are low. An average household can reduce its energy bill up to 10 to 15 %. The same is true for businesses, which can also achieve significant energy savings by using new energy management systems.

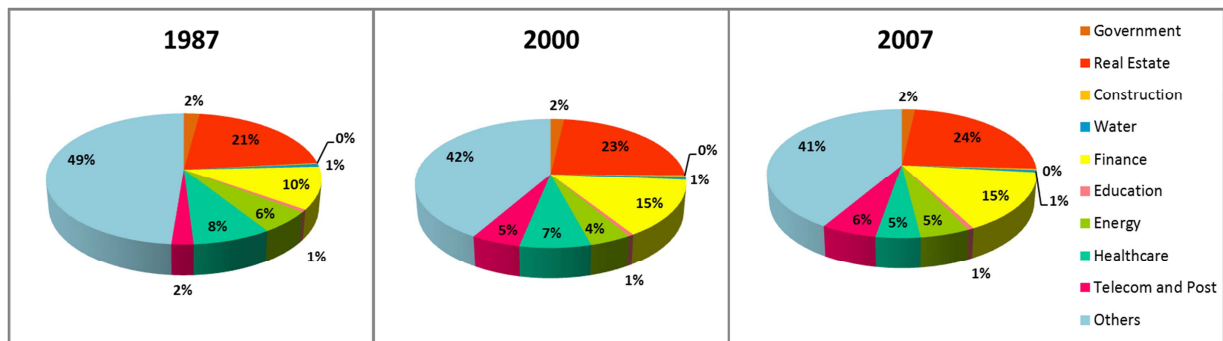
Furthermore, Smart Grids can also use the electric vehicle to provide storage capacity and significantly contribute to the system's balance. Vehicle batteries can be used to store energy when it is inexpensive and capacity is available, and discharge energy back to the grid during times of tight capacity. An

intelligent network platform as Smart Grid can reduce the amount of electricity consumed by homes and businesses and accelerate the adoption of distributed, renewable and clean energy sources, while improving the reliability, security and useful life of electrical infrastructure.

### 4.4.3 Telecom

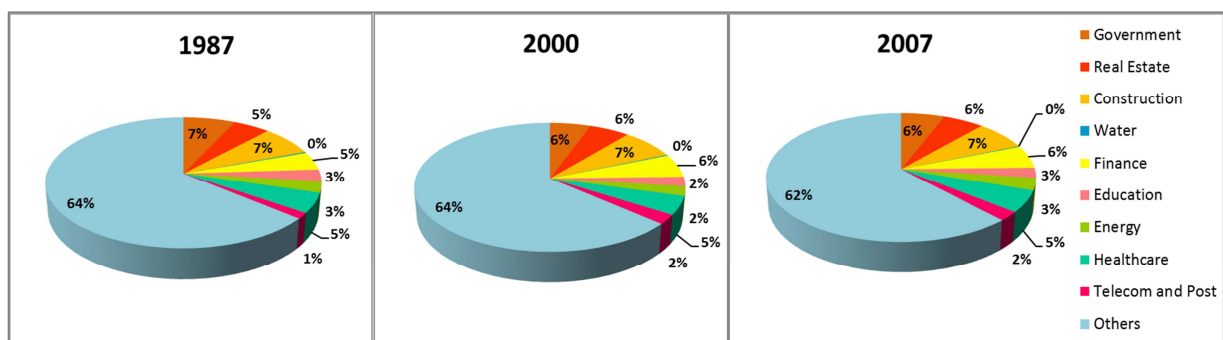
#### Monetary transaction trends 1987, 2000 and 2007

From the Statistics Netherlands I/O data some trends are drawn for the sector selection agreed on with the TRANS consortium to explain the Telecom turnover stated below.



**Figure 44: Total household spending (1987, 2000 and 2007)**

Figure 44 shows the total household spending pie charts for the years 1987, 2000 and 2007. It shows that the household spending on telecom and post had a fast growth (3%) between 1987 and 2000, but from 2000 to 2007 the growth was just 1%. So this shows that household spending to telecom and post is very slowly increasing, while the telecom usage has shown substantial growth as explained in section 4.3.3.



**Figure 45: Total production and spending (1987, 2000 and 2007)**

Figure 45 shows a pie chart of total production and spending on a selected sector set for the years 1987, 2000 and 2007.

#### Telecom production and spending

We see here that the production and spending on telecom and post is only 2% of the total Dutch economy in 2000 and 2007. The production and spending on telecom and post is very small compared to other sectors (only the Water sector is lower). Baring in mind, that the telecom and post activity cluster is one of the top 4 connected nodes in the monetary transaction network (see section 3.3.2) we observe a paradox here. Moreover, during a conversation Professor Nico Baken confirmed this finding:

*“If we look at the telecom sector, we observe how this sector survives in the current highly competitive economic environment. Large investments are required in order to be able to operate in the long term. If*

*we look at the monetary volume of telecom it is about 1.5 to 2%, of the total economy and it only consist of basic telecom services. There is also a small portion which belongs to IT service. This explains how the telecom sector survived so far, and if it keeps on focusing on the classical service delivery (Voice, the Internet, TV and Connectivity) it will not survive for long.” (Professor Nico Baken)*

### **What is the true telecom challenge?**

Below in italics a quote from Professor Nico Baken explaining the impact of the Telecom sector in the transition to the new paradigm:

*The Telecom sector can have a huge impact in the transition towards the new paradigm and the consequences for all sectors. However, this will happen if and only if the Telecom sector understands the current paradigm, its deficiencies, how it evolved and will be able to muster the empathy for other sectors and their challenges, individually and collectively. It will discover that some major features of current paradigm are generally spoken:*

- 1. centralism rather than decentred (local) organisation*
- 2. a place at the end of the business-chain for the “end-user” versus a central position of the actively involved prosumer in the value web where efficiency and resiliency are in balance*
- 3. fragmentation of functions into measurable requirements in stead of integral value sensitive designs*
- 4. hierarchical organisations rather than p2p flat organisations*
- 5. for efficiency’s sake poor relations between the fragments rather than high quality relations as a basis for robustness and resilience*

*As for the evolution towards the current paradigm<sup>12</sup>, we discern that division of labour purely driven by efficiency leads to:*

- 1. a society that is both efficiency obsessed and efficiency obese*
- 2. a mechanism that can only survive through growth*
- 3. an disproportionate dominating role for the Finance sector (partly enabled by the services of the ICT sector)*
- 4. fragmentation of the Supply side such that it cannot meet the integral requirements on the Demand side*
- 5. a financial, economical, social and ecological crisis.*

*In fact, the sector Telecom has accelerated the development towards the current multiple crisis, which is actually a value crisis, by supporting and improving the existing processes of the current paradigm. To turn to its new role, the telecom sector, instead of supporting these processes with ICT, will have to understand what are real innovative and creative value propositions in and over (trans) the other sectors and thereby fundamentally changing the processes and way of working into new value generating and sensitive value webs. It is then that we see the contours of change and transition, a fundamental reconfiguration of holarchies.*

*We elucidate the above by giving some examples.*

---

<sup>12</sup>see e.g. Mind over Matter of Sander Tideman or the Origin of Wealth of Eric Beinhocker



1. Taxi

Yes, we can deliver quite some intelligent devices in a taxi. Think of mobile phone installation, several GPS devices, faxes, cameras, safety installations et cetera to indeed support and improve the efficiency of the work of the taxi driver. However, this is something else than reshaping the taxi business and putting the customer in a more central position. I envision that the customer can transparently see the available cars, their position, the efficiency and customer friendliness rating of their drivers. Then the customer selects a few of them that he feels comfortable with, PN connections are established, he puts forward his request, including destination, destination time and as an extra if it is possible to have a cup of coffee. Propositions return in an instant and then he picks the taxi of his choice and gives his personal rating after the value proposition comes to an end.

2. Proactive health management

It is obvious that this sector is moving towards disaster. Why? Because its adage, its credo is “disease management”, fighting the symptoms of disease. The transition? The new adage is health management with a responsible position for the mindful prosumer<sup>13</sup>. Obviously we see here a change for a transsectoral approach involving the sectors ICT and education<sup>14</sup>.

3. Energy

It is obvious that this sector is moving towards disaster too. Why? Because its adage, its credo is still for 90% fossil fuel and it is not obeying the Trias Energetica<sup>15</sup> (a law that can be easily translated towards all sectors by first formulating it in a more general way “trans the sectors” and then making a descend in every sector). From a historical view we can understand that, but today this is no longer acceptable, even more so if we recognize that the sun donates us 175.000 TW and will do so for some 6 billion years to come whereas we need some 12 TW! The transition will comprise a move from fossil to green energy, central provisioning to local generation and provisioning using smart Smart Grids of co-operative organisations in your own neighbourhood.

As for the transition, it will emerge through these kind of basic examples bottom up in every sector and later transsectoral, plus simultaneously and top down through an awakening<sup>16</sup> and mindfulness for the required new paradigm. In this transition we will discern holarchies with a balance between resilience and efficiency through the optimal number of high quality relations, connections in between the holons involved in the execution of value propositions of each holarchy. In the end it all comes down to morality, see Claude Levi Strauss, Pierre Hadot, and E. Kant. As for the last philosopher, I quote:

1. Was kann Ich wissen?
2. Was muß Ich tun?
3. Was darf Ich hoffen?
4. Wer ist der Mensch?

---

<sup>13</sup> See Prof Dean Ornish and his book *The Spectrum*

<sup>14</sup> See absolutely [http://www.ted.com/talks/ken\\_robinson\\_says\\_schools\\_kill\\_creativity.html](http://www.ted.com/talks/ken_robinson_says_schools_kill_creativity.html)

<sup>15</sup> 1. If you do not have to use energy ... don't! 2. If you do, then use green energy. 3. If you cannot use green energy, than be smart.

<sup>16</sup> See e.g. Peter Russel, *Waking up in time*

## 4.5 Conclusions from this chapter

In this chapter, the main observations are derived from the SN monetary I/O data sets in the period 1987-2007. First the trends in monetary transactions between the selected set of activity clusters corresponding to worldwide recognised sectors are investigated. The total household spending increased most in the Real Estate and Finance sector. However, the household spending on Healthcare shows an unexpected decrease after the year 2006, which is a result of changes in administrative regulation. If a household performs paid services for other households it is considered an enterprise and will be accounted as part of a sector that corresponds with this activity. Currently, the household sector is only a customer of other sectors. It doesn't provide value to other sectors.

In monetary transactions of the vital sectors, the largest transactions are always the internal transactions of that sector, except for the government sector (only after the year 2005). Due to a change in circulation of insurance expenses, the government has invested a huge amount of money in the finance sector after the year 2005. However, the Healthcare sector shows a downward trend after the year 2005. Furthermore, the crash of the internet bubble is most visible in the internal monetary transactions of the Telecom sector, which is the result of large competition in this sector. This crisis in the Telecom sector doesn't yet affect other vital sectors in the short term. Furthermore, the internal transactions of the Energy sector shows a very steep upward curve, which means this sector, is mainly investing in itself.

After looking at the historical monetary trends, the technological trends related to some of the vital sectors are investigated. For this purpose distinguished innovation experts are interviewed. These interviews are used to derive the most important technological trends around Telecom, Energy and Household.

Furthermore, example of ICT usage in Energy, Healthcare and Telecom sector are explained and the importance of Telecom sector as a connection hop between vital sectors is highlighted. ICT can be an effective instrument for a lot of society needs and issues. For the Healthcare sector, it supports with the realisation of telecare and telehealth systems. And in the energy sector ICT helps to realise the Smart Grids in the Energy sector. Vital sectors Telecom and Water have a surprisingly low monetary footprint in the entire sector network.

# 5.

## Data management for Smart Grids

---

*This chapter describes the problem relating to the energy production chain, renewable sources, distributed generation and energy storage. Furthermore, the concept of Smart Grid is described, which offers a solution for integration of sustainable energy sources in the present system. Although Smart Grid is perceived differently by different parties, there are several aspects which many descriptions have in common. Furthermore, we look at the importance of decentralised generation and storage, and compare it with other models. These are solutions that make the house and district energy-neutral, and help them to be independent of the central sources. An energy-neutral society would not rise so fast, but a decentralized system is more robust. Such a robust system will have more impact for the Energy sector. Finally, we describe the role of ICT in the realization of Smart Grid. It brings us to several developments which we explain specifically.*

### 5.1 The current situation and complications of Energy sector

#### **The societal issue of the 21st Century**

Fossil fuels are running out. The average global temperature increases. Sea levels are rising. Extreme weather such as droughts and heat waves are frequent. We can no longer skip this issue; the climate issue is getting increasingly important to society. The world, especially the western society is in a period of great industrial growth and is highly dependent on energy. To generate this energy, mainly fossil fuels are used, and it is still the main source of energy. These fossil fuels are finite and when used causes greenhouse gas emissions leading to global warming, with major consequences for the climate, people and environment.

#### **The world's fossil energy sources are not infinite**

The next 25 years the global energy demand will likely increase by more than 50% [16]. Emerging economies such as China, India, Russia and Brazil will take more than three quarters of this growth in their account. Despite all investments in sustainable energy, fossil fuels (oil, gas and coal) will meet at least 80% of the global energy demand in 2030.

The world is not running out of oil or gas yet, but the global oil reserve is decreasing every day with 85 million barrels. These are 1000 barrels per second. The oil reserve is finite and the way we consume energy is not sustainable. Several studies have shown an increasing number of countries with declining oil production. According to International Energy Agency (IEA), reserves of oil and Natural Gas Liquid (NLG) range from about 1.2 to 1.3 trillion barrels and this is enough to supply the world with oil for over 40 years at current rates of consumption [17]. In recent years, the total electricity demand in The

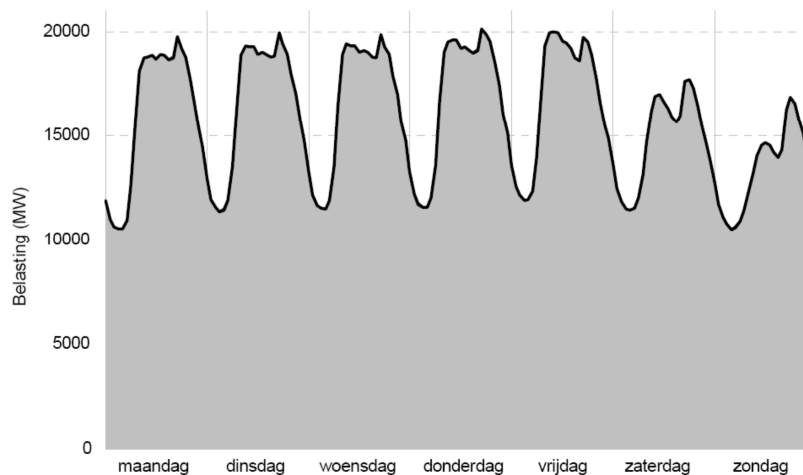
Netherlands is raised with an average of 2% per annum. In 2005 The Netherlands consumed 111 TWh of electricity and by 2012 the total demand will be approximately 130 TWh.

### Slow innovation in Energy sector

According to the study of University of Twente, the innovativeness of the energy sector is fairly low, especially when it is compared with the other sectors. The main difference between energy and other sectors is that the energy sector operates in a supply-oriented market, while other sectors are much more consumer oriented. The life cycle of products in the energy sector is a factor of 3 or 4 larger than those in other sectors. New techniques follow each other in the energy sector. Therefore, it is slower than, for example, in mobile phones and printers. Both the Telecom sector and the Energy sector were first a legal monopoly. Interestingly, the telecom sector has developed into a highly competitive sector and that in the energy sector, much less is done. If we look at the automotive branch of the Trade sector, we see that standard statements have led to innovations such as “Euro standards” for diesel engines. This is something, which can also work well in the Energy sector [18].

### Fluctuating energy consumption pattern

The electricity demand is not constant: the demand at night is lower than during the day, and in winter higher than in summer at the same time during the day.



**Figure 46: Example of one week pattern of Dutch electricity consumption (estimated 2012)**

An example of one week pattern of Dutch electricity consumption is shown in Figure 46. The maximum load is around 6:00 pm in the evening and in the weekends it is lower than the consumption during the working days. As it can be seen in Figure 46, the load has a quirky pattern, but still follows a periodically course. Large (Industrial) customers have pre-established contracts with energy suppliers, thereby it is known how much they will consume and when they will do that. Small customers, particularly households, have good predictability behaviour, due to the large number [26].

### Overview of the electricity distribution chain

The current high-voltage electricity network transports electricity from a central point to many users. Furthermore, the supply is always controlled by the demand and the storage of energy is automatically done in fossil fuels. The system of balance maintenance ensures that the production units adapt to the current electricity demand. This system is not directly calculated on decentralised energy generation, e.g. by solar panels from homes.

The energy distribution has been working for 100 years in much the same way, except for distributed supply of solar and wind energy. The network has few (and only reactive) administration / management. There is no real-time information, on which the network can act. The challenges of the inefficient power system are:

- separated supply and demand causes difference in capacities;
- central management is difficult because of complexity and lack of uniform end-to-end view;
- system reliability medicine seems problematic;
- depend on primary energy sources;
- expensive integration of distributed resources;
- high cost of failure;
- increased risk associated with security issues.

In Table 5, gives is an overview of the energy sector in different spatial ranges.

**Table 5: Energy sector overview**

|             |                | EU/NL   | Regional                         | Neighbourhood                           | Household                                      | Devices                                |
|-------------|----------------|---|----------------------------------|---|--|--|
| Description | Generation     | centralised plant: nuclear, coal, gas, oil, hydro power plant | partly decentralised : wind farm | partly decentralised: wind turbine, CHP | partly decentralised: micro-CHP, solar panels, | solar panels, electric car, TV, laptop |
|             | Distribution   | ≥ 110 kV  | ≥ 110 kV                         | 10 - 110 kV                             | 380 V  | ≤ 220 V                                |
|             | Storage        | PAC, OPAC, CAES   | PAC, OPAC, CAES                  | -                                       | Battery cells                                  | Battery cells                          |
| Properties  | Flexibility    | Low   | low/ medium                      | medium                                  | low/high                                       | high                                   |
|             | Predictability | High  | High                             | medium                                  | low  | low                                    |
|             | Robustness     | High  | High                             | medium                                  | low  | low                                    |
|             | Magnitude      | 100 GW  | 10 - 100 GW                      | 100 - 1000 kW                           | 10 kW  | ≤ 1kW                                  |

### Sustainable energy sources

Sustainable energy is energy that mankind can practically use infinitely long, and by its use the environment and opportunities for future generations are not disadvantaged. Accordingly, all sources which are not covered by the fossil energy sources (coal, oil, gas, etc.) are the renewable sources. One of the essential benefits of sustainable energy is that we become less dependent on energy suppliers and transporters of international oil and gas. Most important renewable sources are listed in appendix D.2.

The main part of sustainable energy in the future will include solar and wind energy. However, these renewables are a solution to greenhouse effect, but they also create a new problem in the Energy sector. These types of power generation will be subject to relatively strong fluctuations. The supply of energy in the grid will depend largely on the availability of sun and wind. Peak load in the grid, also caused by fluctuations in electricity use will inevitably lead to greater losses. This is caused simply by the principle of increased loss due to increasing current. Because of the increasing supply of sustainable energy, it is expected to be difficult to avoid peak loads in the future, and change the supply and demand of electricity to align.

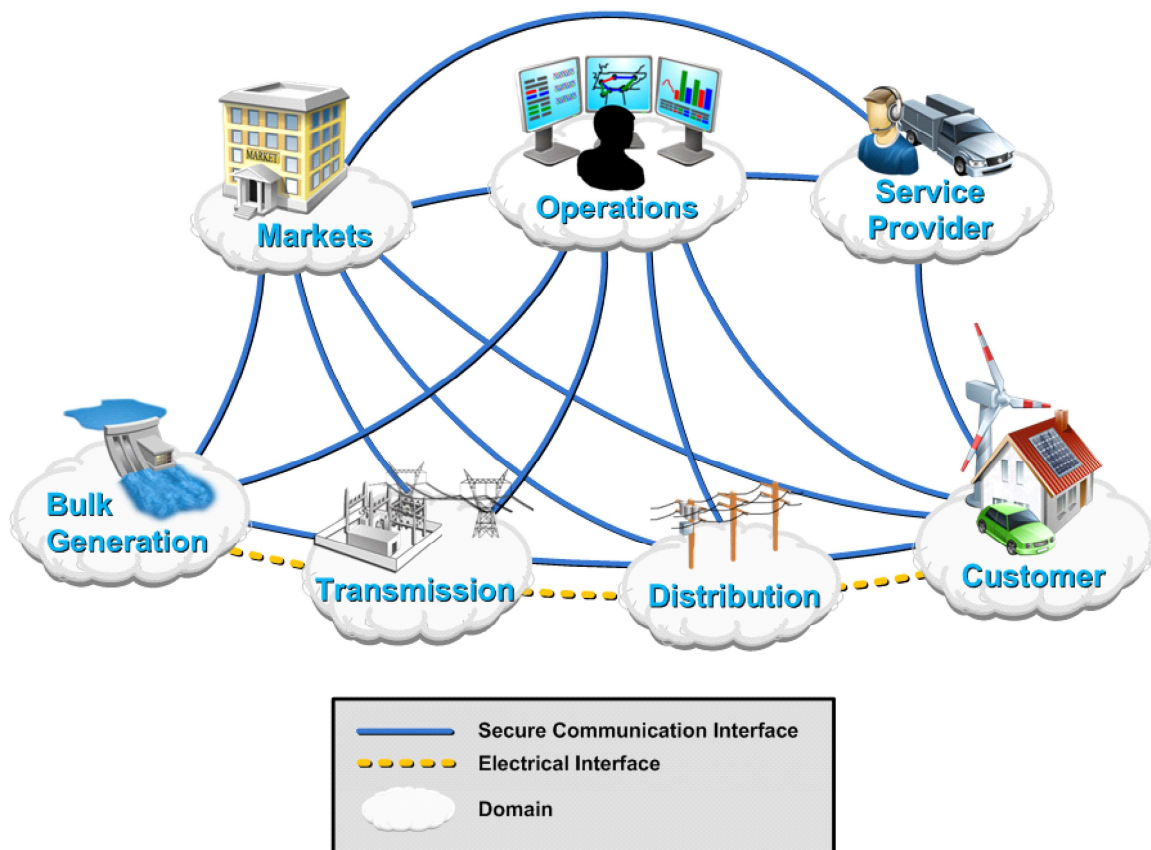
For this problem there does not exist a single solution. There will be a combination of different opportunities for power storage, combined with an expansion and intelligent use of the electricity network should be pursued. Critical to the success of every conceivable size or scale technologies for electricity storage are the energy and power density, efficiency, durability, cost and availability of suitable sites.

## 5.2 Smart Grids

Smart Grids are infrastructures for electricity, gas and heat where ICT systems are added for performing measurements of energy flows and controlling the consumption and production of the energy. Currently, the most prominent definition of Smart Grid is described by International Electrotechnical Commission (ICE):

*““Smart Grid” is today used as marketing term, rather than a technical definition. For this reason there is no well defined and commonly accepted scope of what “smart” is and what it is not. However smart technologies improve the observability and/or the controllability of the power system. Thereby Smart Grid technologies help to convert the power grid from a static infrastructure to be operated as designed, to a flexible, “living” infrastructure operated proactively.” (ICE Roadmap) [65]*

The grids collect information and send it to locations where it can be processed, so the communication would be possible between devices and applications by the energy service provider. Energy price is influenced by the market forces, supply and demand. In case there is a lot of energy the price is low, but if the demand is low the energy tariff is high. In some regions of The Netherlands, there are day and night prices for electricity. However, the difference between these prices is very low. In the future, charging of an electric vehicle at 6 pm will be more expensive than later in the night. Moreover, if you have a wind generator, solar panels or micro CHP boiler, then you can produce energy and sell it to the net.



**Figure 47: Smart Grid domains [51]**

Figure 47 shows the overall high level conceptual model of Smart Grids. This model is design to be as a tool to identify the core areas of information exchange between major aspects of the electrical infrastructure. The blue lines are the secure communication interfaces, and the yellow dash lines are the electrical interfaces, the physical connections, between the elements, and the clouds are the different

domains of the Smart Grid. In general the lower four element represents the electric power infrastructure, bulk generation, distribution and the consumer. And the upper three are the collections of applications and capabilities that interact with all of those fundamental domains the general area of: the market, operation and the service providers. Each one of these domains can be drawn down in additional level of detail.

The term “Smart Grid” is somewhat qualitative, since there are various proposed implementations that have been varying levels of sophistication [25]. However, standard among all implementations is the use of advanced sensor and communications technologies to enable better use of assets, provide improved reliability and enable consumer access to a wider range of services. There are some defining features that exist in most Smart Grids.

#### *Two-way communication*

A Smart Grid will provide an interface between consumer appliances and the traditional assets in a power system (generation, transmission and distribution). This two-way communication will allow the consumer to better control their energy usage and provide more choices to the customer. Furthermore, the two-way communication will also allow better DSM (Distributed Systems Management) such that in certain situations the system operator can be given control of the loads in the system enabling more agile responses to the system behaviour.

#### *Semi-autonomous*

A Smart Grid will be at least semi-autonomous. The use of intelligent systems will enable the power system to respond to stimulus, observed through sensor networks, with limited input from a human. This will enable much faster operations when handling interruptions in the power system and may even be able to identify areas of concern and reconfigure the power system to mitigate potential contingencies.

#### *Optimization*

A Smart Grid will optimize the assets of the power system. The use of responsive operating protocols will optimize power flows along existing transmission, thereby improving the reliability of the system and deferring capital expenditure on transmission upgrades. Due to the communication of peak load periods and the likely subsequent consumer response to increased price signals, the peak loads will be reduced and the need for expensive flexible generation technologies will be reduced.

#### *Integration of distributed generation*

A Smart Grid will support better integration of distributed generation into the conventional centralized power system. Improved communications and more advanced metering technologies will enable more intelligent incorporation of decentralized power production through the use of better sensors and two-way metering. This will allow customers (whether residential, commercial or industrial) to re-evaluate the proposition of connecting local generation equipment. The customer could be an energy supplier as well as an energy consumer who is a producer-consumer or “prosumer”.

#### *Distributed control*

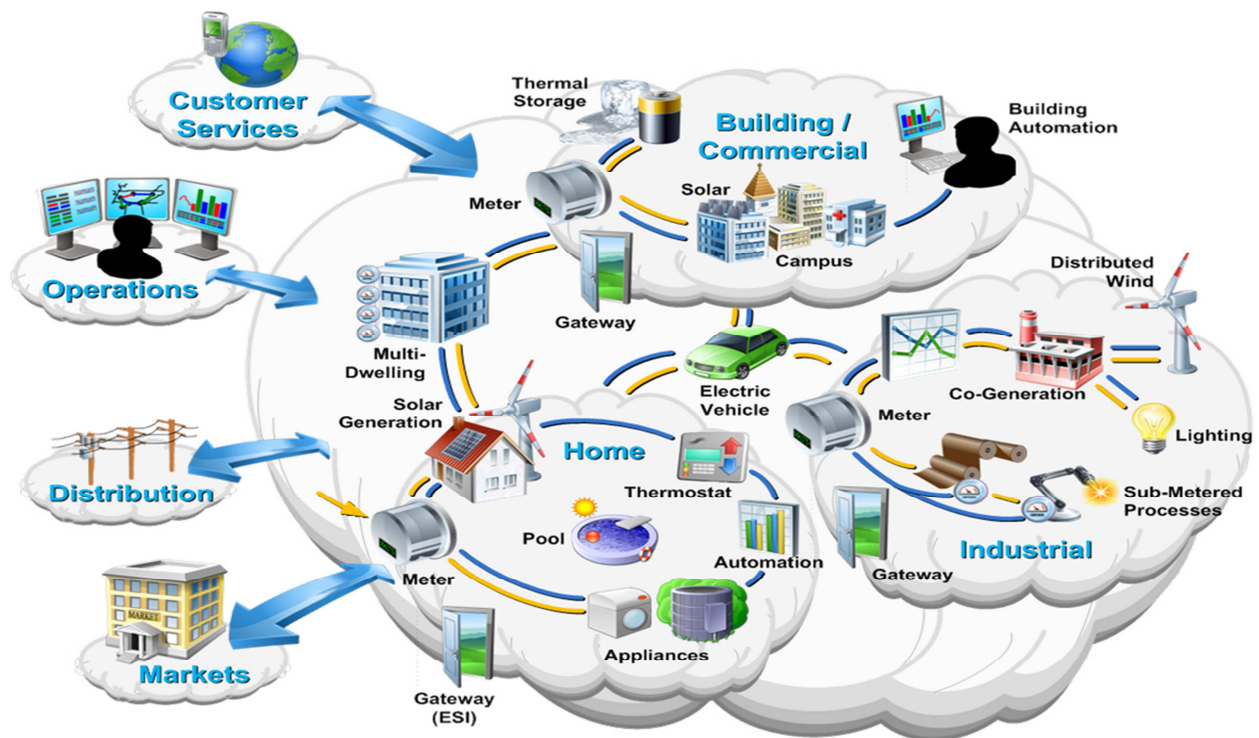
A situation in which the decision-making and load balancing of each power source is performed locally, is commonly referred as distributed control. In this way power system is more robust to the outage and more scalable. Accordingly, if the power sources and loads follow a common communication structure, the addition of new power sources to the system will be easier than the traditional way of integrating new sources into a centralized control strategy.

#### *Distributed generation*

Distributed Generation (DG) of electricity is part of a new and more sustainable electricity generation from many small energy sources. It is supposed to enable the electricity consumers to have some degree of energy independence and transform the bulk power system open to small energy suppliers.

The Dutch electricity market players consider distributed generation as the sum of all assets not covered by the TenneT observation. Generally, these are the units of <60 MW installed capacity.

Some important benefits of DG are as following. DG can provide a significant environmental benefit, if the DG system uses sustainable energy. Furthermore, because the electricity is generated very close to where it is used, it reduces the amount of energy lost in transmission of the electricity. A brief explanation of this type of energy is given in appendix D.2.



**Figure 48: Smart Grid customer domain [51]**

Figure 48 illustrates the consumer domain within NIST’s Smart Grid Conceptual Model Domains needs standardized information models supporting real-time and historical energy consumption data.

If we look at the customer domain we will see that it is further subdivided into three customer areas of: commercial, industrial and home domain. By Identifying some of the key elements that need a physical and communications kind of activity to implement the various applications and functions that are identified and addressed in the roadmaps of NIST. Some elements are shared across multiple areas, so the electric vehicle is shows to be connected to each three of these domains. And some show characteristics of more than one subdomain, in the case of muti-dwelling building, for example, they share characteristics of the residential side plus other characteristics of the commercial side. The applications such as smart electricity meters, which regulate the energy consumption in a household and distributive energy generation for the electricity network, are increasingly used.

Although the potential of the “Smart Grid” is increasingly recognized by society, a cultural change must take place before there is a success. To achieve in the right direction, it is important that companies and individuals are informed about how the “Smart Grid” should be used to guarantee security. In addition, the investment needed to secure digital grid to prevent fraud.



In a future scenario with a lot of wind or solar energy (systems that have a somewhat stochastic behaviour), that is generated at a place other than where it is consumed, there is probably more “rural” information needed than in a scenario with micro CHP boilers and batteries at home.

Green energy has been spearheading Dutch energy policy for some years. Political uncertainty concerning sustainable energy is compounded by an increase in the overall energy demand. In its climate policy, The Netherlands set a global target of 5% sustainable energy by 2010, and 10% by 2020 [19].

A Smart Grid can be flexible to deal with a varying range and a fluctuating demand for electricity. This makes it suitable for electricity produced in many locations and to compensate the fluctuations of different energy providers such as solar panels and wind mills. Furthermore, soon smart applications will be available, which can help users control the in-home devices from distance or automatically based on collected information (using daily agenda and energy tariff information).

## **5.3 Decentralised generation and storage**

In on-side energy generation, new energy saving technologies, such as the CHP and electric vehicle, are getting more and more important. Hence these technologies lead to a decline in total energy demand, but ensuring an increase in electricity demand. This increases the electricity consumption of a household. For example, a household with an electric car is expected to consume more than 3000 kWh per year to about 9,000 kWh per year - almost tripled. On the other hand, the energy production makes a transition from a centralised generation to sustainable energy forms as explained in appendix D.2.

Solar thermal energy (solar collectors), Hydro and solar PV will be probably the biggest global markets in 2020, shortly followed by biofuels and wind. Hydro is the largest market in 2008, but grows relatively limited until 2020 [19]. The sub-markets for sustainable energy are in various stages of development. Some markets have grown to call and encounter fewer obstacles in further development. The markets of Hydro, insulation, onshore wind and co-firing of biomass fall within this category. Other markets are still relatively new and are characterized by many players and dynamics, positions are still occupied. This is particularly true for E-mobility, LED lighting, Biorefining and Biofuels (see appendix D.2 for detailed information about these renewable sources).

This change in electricity generation leads to the independency of the end-users from an electricity supplier. Furthermore, the electricity infrastructure (which in large part originates from the 60s and 70s of the last century) is aging and needs a life cycle management. Therefore, the time is ripe for a change in the energy sector.

### **5.3.1 Future Microgrids**

The current electricity grid is based on central generation in a limited number of electricity plants. After generation, the electricity is transported over long distances before it reaches the user. This centralized production stands in contrast to the production of electricity near the user, which is described as distributed generation. The latter occurs with so-called distributed power generators (Distributed Generators) using the local energy generators such as Combined Heat and Power (CHP), PV systems, wind turbines, etc. [21].

This way of generation is becoming increasingly competitive with centralized power production. There are two reasons for this increased competition. First, the small-scale production technology is constantly improving. The potential for combined production of electricity and heat are far more

affordable now. Secondly, the price of Distributed Generation (DG) technology decreases and the price of transmission technology increases.

Microgrids offer a solution for small distributed power generators to integrate on a large scale into the low voltage networks. Micro-Grids are power distribution networks in which consumers and generators of energy are in close proximity of each other<sup>17</sup>. A micro-grid is a subnet situated on the secondary side of the MV/LV-transformer of such a district or a mall. Regarding the operation of these micro-grids, there are two business forms: the grid-connected form and the islanding form.

In the grid-connected form, the microgrid is connected to the electricity distribution system and supply electricity to the grid. In island form, the microgrid is completely independent and is responsible for its own electricity production. However, the independence of islanded operation is not allowed according to Electricity Industry Law (islanding prevention)<sup>18</sup>. A microgrid can include CHP (Combined Heat and Power), photovoltaic systems, fuel cells, but also energy storage systems such as flywheels, super caps, batteries, etc. It also includes variable loads because islanding power output need to be in balance with the demanded power. In comparison to the public distribution system, a micro-grid behaves like a decentralized controlled entity. With the combination of generators and loads the micro-grid can seamlessly move from a grid connected to island operation mode and vice versa. Therefore, it can relieve the network in times of heavy load and to help recovery after an error [22].

In the future the share of alternative energy sources in electricity production will strongly grow. This will evolve from large central power production units to increasingly smaller production units. Since alternative sustainable energy is not always available there will be more fluctuating energy supply. The balance between demand and supply will not be regulated primarily by the supply side, production, but by the demand side, consumption. Currently, the electricity suppliers indirectly encourage the load distribution in the residential and tertiary sector, e.g. through a day-night rate and a weekend rate. This does not allow matching of the electricity demand with the fluctuating energy from sustainable energy sources. In order to best respond to the fluctuating energy an active and intelligent attitude of electric energy consumers is needed, this is called active demand.

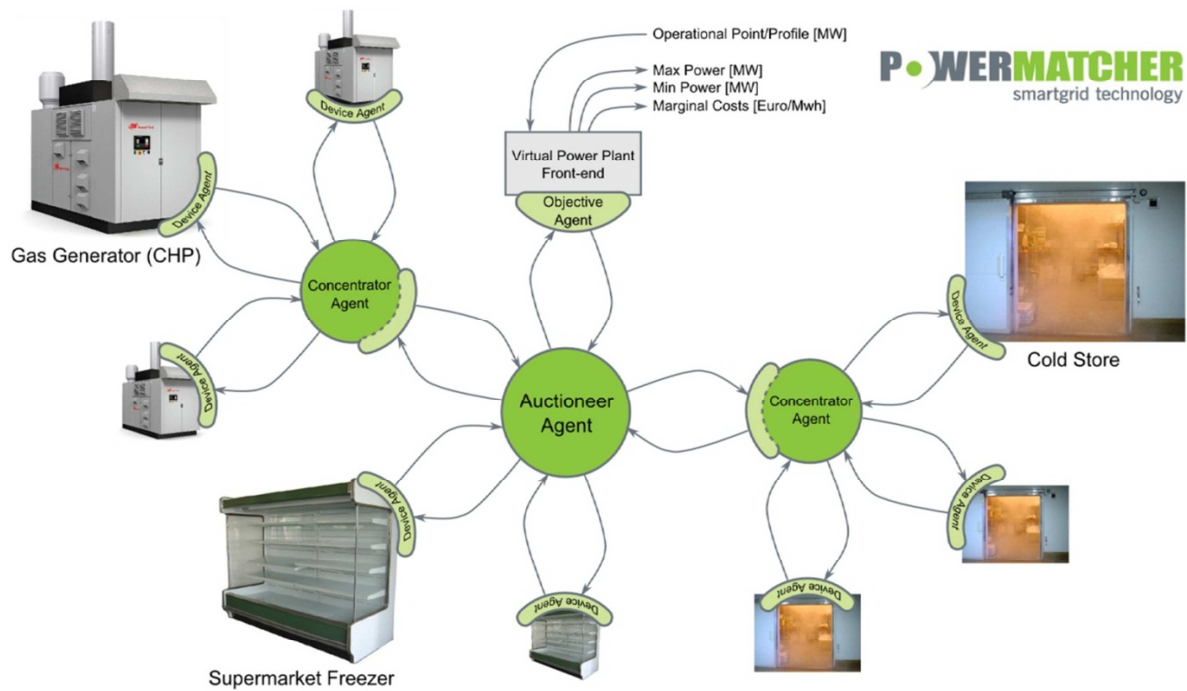
### **PowerMatcher (decentralised control)**

Researchers from the energy research foundation ECN, in The Netherlands have found a new coordination system with the PowerMatcher, which can tune to demand and supply of electricity more efficiently to reach equilibrium. The PowerMatcher is an ICT solution that connects devices to the systems of energy market and network management, making use of flexibility of the end-user. This could be an important building block for the Smart Grid of the future, considering the decentralised manner of this system.

---

<sup>17</sup> See on-going research on Smart Microgrids Modelling (e.g. paper: Vaccaro, Popov, Villacci, Terzija) [60]

<sup>18</sup> “An islanded micro-grid refers to the creation of a system that is never interconnected with the area grid and as a result could be granted greater flexibility by state regulators and might not be subject to regulation.” [66]



**Figure 49: PowerMatcher - Basic Structure and Agent Roles [23]**

In this concept, each electricity producer and consumer are represented by an agent acting on a virtual electricity market (implemented by the Matcher). In this way, the price is dynamically created depending on supply and demand. The concept can be applied at different levels as the house (the fridge does business with the solar panels), at the district level (houses do business with a sub-station) or even higher level. ECN is already running a cluster of houses in Hoogkerk (Groningen), within the framework of the related project INTEGRAL. Micro Energy Generation uses sustainable energy sources as mentioned above, e.g. solar, wind, micro-CHP, etc. This actually results in bi-directional power flows in the grid. Considering that currently the major power suppliers are the large centralised plants, the rising injection of more sustainable energy will show insufficiency of the current grid design. The problems that come along are mainly the network protection, lack of communication with distributed generators, and independency of local generation. Therefore, there is a need for micro energy generation services that can control and coordinate micro energy negation units in the distribution grid.

### 5.3.2 Decentralised energy storage

Energy storage techniques are used to balance the supply and demand of electricity in a power grid. For large-scale load balancing of an interconnected electric network, the energy producers send the additional off-peak cheap electricity through the transmission system for energy storage sites for temporary storage of energy. The energy storage locations become energy producers, when electricity demand is high. This reduces the cost of peak electricity demand, by providing the energy for use during peak demand without additional investment in excess capacity that most of the day would not be used.

#### Micro combined heat and power (micro-CHP)

In the coming years there will be a rapidly growth in the number of small-scale intermittent renewable resources connected to the electricity network. In addition, we will also have a growing number of small fossil-fired generators (micro-CHP units) for households and businesses. Integrating these smaller sources affect the business of the network. Through the use of small-scale storage systems, these generators are used optimally and may also be increased uptime of networks, by reducing the peak load (both supply and demand). Moreover, through a “black box” with small storage at the customer, rather than through the

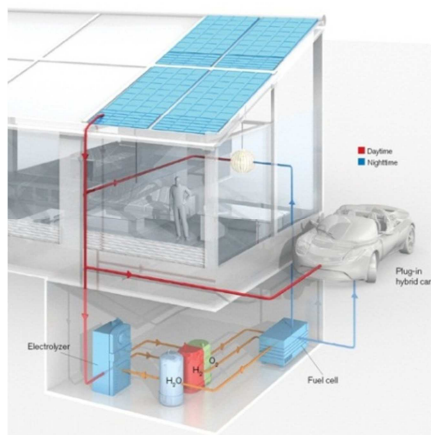
regulatory mechanisms in large scale production, the reliability of the network can be realized in a different way.

### Storing electricity in batteries

Different institutes are focusing on the storage of electricity in lithium-ion and redox flow batteries, which until now is only used for storage on a small scale. Lithium-ion batteries have a relatively high energy density, and therefore, it is of great interest to the automotive industry for use in electric and hybrid vehicles. The recent developments in electron mobility show also an opportunity for electricity storage: if in the future a large number of cars are equipped with a large lithium-ion battery, the vehicles which are parked and are connected to the grid can also be used as conventional storage. One study showed that if 10% of all cars in Germany drive with lithium-ion battery. The current storage capacity will be doubled. Particularly, the cost of lithium-ion batteries is still an obstacle to the widespread adoption of this technology. A cheaper option is deploying redox flow batteries. The charge carriers consist of liquid electrolytes. The use of such batteries in vehicles is still impractical, because for driving a vehicle to an acceptable distance, hundreds of charge carriers would be required. For electricity storage designed to stabilize the electricity supply system, the volume is not the problem, but it does indicate that to optimize the energy density of these redox-flow batteries more research is needed. The main benefits of this change are fair energy prices and the lowest network charges. Moreover, the supply of vital networks will remain in public hands. This helps to achieve the goal of fair competition and reliable networks.

### Vehicle-to-grid (V2G)

The Vehicle-to-Grid (V2G) is a new technology, introduced by the team of Willet Kempton at University of Delaware, for electric and plug-in hybrid vehicles to enable delivering of electricity into the grid or controlling their charging rate [24]. When the car is in the V2G setting, the battery's charge goes up or down depending on the needs of the grid operator. The idea is to take advantage of the electrical storage capacity in the vehicle's battery during the times when demand is highest and most costly to avoid blackouts. Figure 50 illustrates how the combination of solar electricity production, storage in electrical vehicle and hydrogen cell in future Smart Home is achieved. During the daytime, the solar energy is used to produce electricity and whatever is not used is sent to the electrolyser to be converted into hydrogen, or directly passed to an electric vehicle.



**Figure 50: Smart Home electricity production and storage example**

Studies show that in the developed countries millions of cars are parked an average of 90 % of the time, even for the “rush hour”, so it is possible to use their batteries to feed back to the electricity network or provide power to home or businesses on occasions of high electricity demands. Car batteries, when treated in an aggregated fashion, represent a considerable level of distributed storage capability. In particular, V2G concept has an important basis for further development due to efficient usage of their power output in highly fluctuating wind power generation [26]. For a country as The Netherlands with a large number of

wind farms, V2G is an interesting technology to make very large scale wind integration more stable and more economical.

The research group of the Fraunhofer Institute for Solar Energy Systems ISE in Germany already developed an intelligent charging station, which can adapt recharging times to suit energy supply and network capacity. One of the unique advantages of electric vehicles is their capability to integrate the transportation and electric power generation sectors in order to improve the efficiency, fuel economy, and reliability of both systems. In shorter-term first CO<sub>2</sub> emissions of conventional cars will be even further reduced. For long term, we must switch to sustainable produced energy carriers. Then we come out with vehicles powered by electricity, bio-fuels or hydrogen. However, sustainable public transport is also a major option. Possibly, some of the options will be killed in the 2050 race to sustainability. Therefore, it is important to bet on different horses.

### **Large-scale storage methods**

An energy storage system, which is used for decades, is pumping of water in large reservoirs and when the energy is needed, the turbines can be driven by deflation of the reservoirs (see appendix D.2). In Switzerland and Norway, where many such reservoirs exist, this method works well in combination with nuclear power plants that produce electricity continuously day and night. However, in Netherland and northern Germany, the places where a lot of wind is available, the construction of large dams is not feasible or it is expensive to build.

## **5.4 Computational and Telecom capabilities for Smart Grids**

### **5.4.1 Monitoring and management of the electricity network**

A reliable energy supply is essential to society. In our modern world electricity plays a great role. Moreover, it is an indispensable role. So the power outage is very expensive for electricity network and the country itself. A potential outage can be prevented if we have insight over the entire network, and it can easily be managed. Nowadays, electricity network providers are installing sensors in their network nodes to sense and monitor the possible failures and control them in real time. Each segment of the grid has an operation centre that conducts and coordinates various functions, including system monitoring, control, crew administration and dispatch. It has been regarded conventionally as “the brain” of the power system, from which operations have been directed. The automation of grid operation and management are usually done with Supervisory Control And Data Acquisition (SCADA) systems [27]. SCADA is the traditional ICT system for power grid, which functions as a control plane for the communication network. The SCADA system uses closed technologies, which brings interoperability issues. Another problem with SCADA systems is its limitation to transmission network.

### **5.4.2 Storage management of electricity**

Ever-growing integration of renewable electricity generation has also increased the need for more flexibility of the electricity supply system. This flexibility is provided by adjustable gas power plants, adjustable coal gasification plant, controllable load, CHP (heat-power coupling) with heat storage, future VPP (Virtual Power Plants), Smart Grids with a mix of variable local load storage and generation, inter-connectors, mass storage, external water storage tanks associated with High Voltage Direct Current (HVDC) cables, heat pump, batteries of electric cars, etc. All of these need intelligent communication, to

be controlled and monitored. Therefore, an ultimate societal balancing method is necessary to have control over this complex system.

### 5.4.3 Cloud computing

Comparable with Smart Grids the cloud computing has been submitted to a lot of definitions by different organisations. The hype is so strong that there are 22 different definitions of just what cloud computing is as everyone tries to glom onto the buzz of cloud computing.

*“Clouds are a large pool of easily usable and accessible virtualized resources (such as hardware, development platforms and/or services). These resources can be dynamically reconfigured to adjust to a variable load (scale), allowing also for an optimum resource utilization. This pool of resources is typically exploited by a pay-per-use model in which guarantees are offered by the Infrastructure Provider by means of customized SLAs” (Vaquero et al) [28]*

In other words, the clouds are hardware-based services that can provide computing, network and storage capacity. Cloud computing is divided into different models (IAAS, SaaS and PaaS):

- *Software as a Service (SaaS)* is the ability to use software that is licensed by the supplier and running on a cloud infrastructure.
- *Platform as a Service (PaaS)* is the possibility of software, which is created by a user with programming languages and tools from the supplier, to run on a cloud infrastructure.
- *Infrastructure as a Service (IAAS)* is the opportunity to make use of processing, storage, networking and other basic computing resources for running arbitrary software.

Furthermore, cloud computing is divided into different types (private, public, hybrid, community):

- **Public Cloud:** available for general public.
- **Private Cloud:** available for organizations.
- **Community cloud:** It supports a specific community consisting of several organizations that have shared interests (mission, security, policy)
- **Hybrid cloud:** composition of two or more cloud types (public, private or community), which are connected by standard technology.

### 5.4.4 Smart Metering

A smart meter is an electronic meter that allows utility companies to build additional features or subsequent modules for collecting the recorded meter readings, on distance. A smart meter will replace the analog energy meter (e.g. polyphase meters). In addition, the existing gas meter will be accommodated with a digital reader, so that the gas is digitally measured and the meter data can be forwarded to the smart meter.

The smart meter can relay meter values every 15 minutes to the grid operator. In addition, it contains different ports which can remotely control device on distance. Hence, through an electrical signal it can shut down an electricity line, for example when there is default or (imminent) overload of the network.

A smart meter provides suppliers in addition to the simple energy supply also the possibility to offer energy services to their customers (e.g. energy saving advice), and secondly it enables the network operators to optimize the operational management of their network.

### 5.4.5 Required telecom capabilities for Smart Grids

It is expected that there will be no ground-breaking new telecom functions required for the information exchange of the Smart Grids, and it is sufficient to combine features from the current portfolio.

Virtual power plant is a new accounting concept (between households and traditional energy suppliers) that can be delivered from the telecom sector. The household will receive a fair calculation and settlement

system for decentralized energy generation. In this way, households will be stimulated to produce sustainable energy and at the same time use new telecom services.

Currently, in a pilot setting, the Energy sector is testing Smart meters using data transfer capabilities provided by the Telecom sector. The telecom sector retrieves and stores this data in a database, so the electricity network operator can decide who can get access to this information.

Moreover, now only 30,000 customers connected to a smart meter. The Ministry of Economic Affairs has initially ordered to standardize the minimum set of basic functions, like: on distance readable metering for electricity, gas, thermal energy (heat and cold) and water for small consumers.

Telecom companies can provide the energy consumption usage information for the households to help them save energy. This might be done by intelligent applications showing graphs of daily usage patterns and show them through a special TV channel or an application on their smartphone. Thereby the households might be advised to use electricity when it is cheap.

## 5.5 Conclusions from this chapter

Based on worldwide consensus the Energy sector aims at “50% less CO<sub>2</sub>” in 2050 and “20% less CO<sub>2</sub>”, concerning the implementation of a sustainable energy generation, consumption and pollution control approach.

There is no orchestration in place for governing centralised and decentralised generation and storage.

The expected spectacular energy consumption increase mainly caused by BRIC countries will force a new sustainable energy ecosystem. The timing is still fiercely debated.

Some complications around Energy sector innovation towards energy generating households are:

- Companies and households can be feed-compensated for the energy supply back into the macro network.
- The pattern of restitution in a centralised-decentralised supply system is more irregular compared to a classical centralised supply system. These supply-demand fluctuations in a centralised-decentralised situation complicate the operations for the macro electricity suppliers, and as well reduce the commercial attractiveness.
- The European standardization of Smart Grids is still in its infancy.
- From one-way to two-way communication requires consumers who benefit from it or like it.
- A Smart Grid using smart meters can reinforce the network load and the increase of production capacity by growing demand.
- Results are achieved quickly in response to the market demands other than in a central control lining.

The energy issues are not resolvable within the limits of the current energy system. There is a need for:

1. research and development effort,
2. the behaviour of energy users has to change,
3. infrastructure should be adapted to the transition to a sustainable energy system.

The importance of this energy transition is realised by households and businesses more than ever. Rising energy prices provide an additional incentive to be more economical with energy and invest in sustainable energy. This momentum must be used right now to take steps towards an energy management where future generations can also live with. The expected near future energy generation situation in The Netherlands is likely to be a mixture of (classical) centralised and novel decentralised (home / neighbourhood based) energy generation. Concerning the storage of energy a comparable shift can be expected.

### Storage

In the future, the electricity system will need more flexibility because wind and sun have varied electricity supply. Therefore, it is difficult to optimize and control the total power supply. One way to increase the flexibility is the addition of more buffering capacity in the system. Large-scale storage systems can help to maintain the balance in the system, which can accommodate peaks in production surpluses or deficits.

### Smart Grids

A Smart Grid is a step towards a solution to the requirements that will be expected from the electricity infrastructure, in the coming decades. Its introduction will not automatically expire. New technologies must be developed and implemented in existing networks without any provisions. Smart Grids will be included in the plans for replacement investment. The changes will also ask the legal frameworks and have an impact on investment models and commercial frameworks for the electricity system.

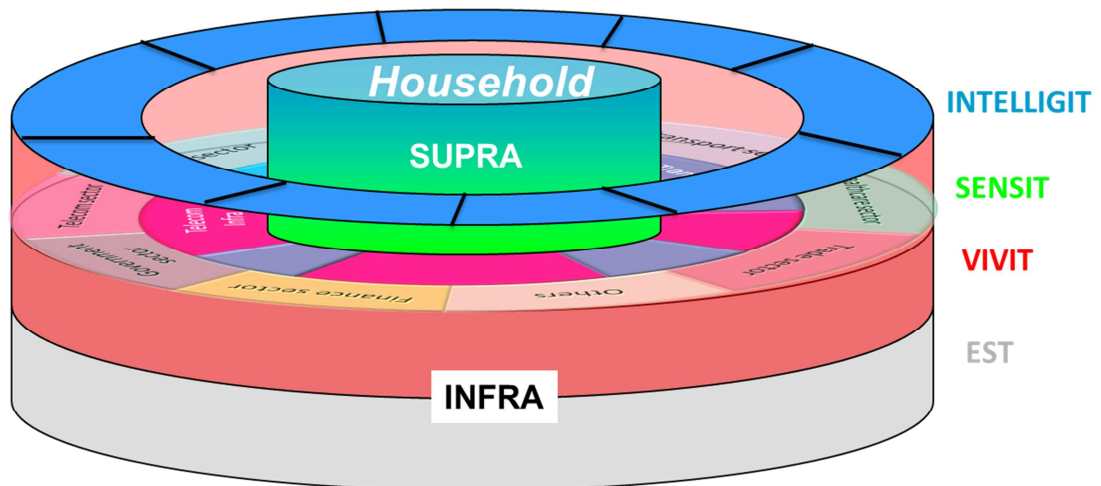


# 6. Developments of devices for Smart Home

*This chapter discusses the main in-home related developments. The different categories of in-home devices correspond with specific sectors that are connected to the household. Some of these sectors are physically connected to the home by means of their infrastructures e.g. the Energy, Telecom, Water and Transport. Furthermore, we explain in detail the home and networking technologies, for the interconnection of the devices. To transform the typical contemporary houses into future Smart Homes, the problems such as interoperability and complexity of the interior configurations have to be resolved.*

## 6.1 The home as a holon in the sector network

The Household sector, like all other sectors has a SUPRA and an INFRA layer. SUPRA refers to the services and soft values that households use, and the INFRA refers to the infrastructure part inside the house. The infrastructure inside the house is the convergence point of infrastructures from other sectors.



**Figure 51: The home in the sector network**

Figure 51 illustrates which infrastructures are physically connected to the household. Also other sectors that don't have own infrastructures are connected to household. Those sectors use the infrastructures from other vital sectors to reach the household. In this chapter the focus is dedicated to the INFRA part of the household. Following the discussion of social and technological developments of chapter 4, we can distinguish the following trends related to the home:

- In the coming decades we are dealing with a strong ageing population, which calls for inventive solutions to the rising demand for care.
- With the growing individualization there is increasing demand for personal services.
- In the current economic situation with low consumer confidence, there is a reluctance to invest in comfort and luxury.
- New multimedia and entertainment products take the place of old products, and the old ones slowly disappear.
- Continuous health monitoring is becoming increasingly important.
- The need for secure connections so that information is available anywhere and anytime is increasing.
- More and more people use the Internet as a source of communication and as a working place.
- The number of broadband connections in the house is increasing sharply, as many devices are getting connected to internet.
- Mobile communication is becoming more prominent and consequently its importance rose up drastically.

## 6.2 Smart Home concept

The concept of Smart Home builds on the home automation concept, and it is been widely researched by lots of universities, institutes and companies. A Smart Home can be described and defined in many different ways. A Smart Home today generally raises ideas about refrigerators that can tell you which products are expired and what meals you can prepare with the ingredients currently kept in your fridge (Park et al., 2003) [29]. Other so called future homes are completely integrated with media services so that music, movies, and pictures are available in every room of the house (Fasbender et al., 2008) [30]. A prime example of this is Bill Gates' house where visitors wear a chip that identifies the person and plays their favourite music as they enter a room in the building (Venkatesh, 2008) [31]. Energy suppliers see something different in the Smart Home. They see complete energy efficiency being built into the new homes such as warm air that is leaving the home heating the cooler air that is replenished (The economist print edition, 2008) [32]. Furthermore, special windows to isolate from the elements and water saving solution are all part of the energy efficient house of the future according to the energy suppliers. Other say the Smart Home will be something for everybody at one day, not only the wealthy. With the prices of computers dropping and computers becoming readily available the future of ubiquitous computing becomes a reality (Bull et al., 2004) [33]. Embedded chips into everyday objects allow for machine to machine communication and ambient intelligence being created by a whole host of sensors that are being implemented in the modern home (Helbig and Tan, 2003) [34]. Thus we see that the services and technologies that will be incorporated into the home of the future are ever changing and dependent on the perspective of the organizations supplying the products and services. The description of Smart Home varies within each context like we saw above. The most likely definition of Smart Home is given by Richard Harper:

*“A “Smart Home” can be defined as a residence equipped with computing and information technology which anticipates and responds to the needs of the occupants, working to promote their comfort, convenience, security and entertainment through the management of technology within the home and the connections to the world beyond”.* (Aldrich, 2003) [35]

Everyone has more or less attentiveness for applications in the fields of Smart Home. Gann, Barlow & Venables (1999) identify four types of households that would have most benefits from a Smart Home [36]. These are:

- Households where both partners work
- Highly mobile and single person households
- Families of middle-aged
- People with reduced physical capabilities such as the elderly and disabled.



**Figure 52: Smart Home view**

Our houses are filled with household appliances as we can see an example in Figure 52. Everyone has a refrigerator, a washing machine, dryers and dishwashers. These devices are clearly taking their place inside our houses. We become dependent of these devices on many fronts. They save us time and effort and to simplify our life, for example we can prepare every food in the kitchen and our living comfort is considerably increased.

## 6.3 In-home device groups

Often people choose for a device which has different functionalities. Different applications which are mutually reinforcing the functionality of the whole have greater effect than the sum of the functionality of individual applications. That is particularly the case when services are linked to applications. The possibility of insight into the energy for residents, could lead to energy savings and the savings can be increased by the energy suppliers to access this information for remote management. Sometimes the pairing of a service is necessary for an application to function seamlessly. In-home device groups can be categorized in five domains:

1. Energy Management
2. Security and Access Control
3. Healthcare and Assistive Computing
4. Home Entertainment
5. Home Automation



**Figure 53: Grouping of in-house devices**

Figure 53 shows the five categories mentioned above. This distinction is not a strict separation, most of the time the different applications run together.

### 6.3.1 Energy Management

Integration of networks and equipment not only provides additional functionality, but also enables home energy management. Despite the fact that electricity consumption has risen significantly in recent years, the opportunities for energy management are mainly focused in the field of electricity consumption. In addition, 60% of the cost of the energy bill can be allocated to the heating of the house and hot water<sup>19</sup>. In general terms, energy management occur at the product level, managing the installation behaviour of residents and maintenance of the installation. The energy management systems can help by:

- Maintenance and repair of HVAC, lighting, water and power systems
- Temperature control and automation
- Installing energy efficient equipment
- Managing meters, alarms and emissions
- Usage tracking and analysing data
- Reporting, analysis and planning ahead the energy demand
- Analysis of energy pricing and billing
- Advising on the purchase of energy and energy services

### 6.3.2 Security and Access Control

The security related in-home devices are often referred to as surveillance devices. The scope of surveillance and access control can be broadly divided into personal safety and security. In addition to actual security achieving the sense of security play an important role. The usefulness of personal safety is indicated by the following figures from Consumer Safety institution (“*Consument en Veiligheid*”). Statistics show that the safety and accessibility in housing is required in a large scale. Every year 155.000, 65-seniors end up in First Aid, private inclusions, in hospital or at the house doctor.

In recent years these disturbing alarming figures have put organisation in motion to take the necessary steps. An increasing number of houses will be build and reconstructed to make them more suitable for the elderly. Additional to construction work ICT can contribute for this purpose. Moreover, personal safety is not only intended for elderly but it is useful for everyone. Access control systems are utilised in many different companies and organisations for a range of security management issues. In the most sensitive of high security applications, advanced biometric recognition systems can positively identify the authorised user, eliminating the risk of intrusion via stolen access mechanisms.<sup>20</sup>

The home-surveillance system is responsible for image analysis and alarm decision. When an intruder or other exception is detected, the home-surveillance system will send an alarm message to the remote mobile device and wait for further instruction to be sent by the mobile device to determine what to do next, for example, to establish a video streaming session between mobile and home devices so that real-time video of the intrusion can be shown on the mobile device. Electronic Access Control (EAC) and CCTV surveillance systems have historically co-existed throughout secure installations as two functionally separate and non-communicative systems.

---

<sup>19</sup> Source: Eindhoven Dagblad, 2003

<sup>20</sup> Source: <http://www.adacs.com.au/SubId.aspx?id=34&title=Access+control+systems+and+CCTV+systems>

### **6.3.3 Healthcare and Assistive Computing**

Current projects in which home networks are used within the house, the main focus was on healthcare (see appendix A). Within the residential healthcare, the distinction is between active alarms, preventative care and social contact. With active alarms, a resident can call for help in case of emergency. Preventive care, however, is more focused on identifying symptoms that may indicate an impending emergency. Social contact affects the welfare of residents and hence the health care situation. Outside the home environment applications such as availability of patient information, consultation via email and conference between specialists play an essential role for fulfilment of healthcare processes related to residents.

With active alarm, we refer to the ability of residents to operate the alarm in case of an emergency. Products that are used are: call units with speak-listen connection, neck stations, pull cords and peer printers. After an emergency contact is made with the injured residents to help and/or call their acquaintances. This contact can be established through an emergency centre. The emergency call is handled by using a predetermined protocol. In this situation, the resident himself has to take action.

However, there are more initiatives in the field of preventive care. You can think of telemonitoring, which focuses on monitoring and surveillance. The variant which is used in healthcare projects currently is the inactivity measurement. By using motion sensors and / or detection of water usage in home it can be determined whether an occupant gave a sign of life during a certain time interval. If this is the case, the emergency centre preventively contacts the resident to verify that everything is all right. The monitoring of residents can go much further. In the field of telemedicine following information may be collected from the residents: blood pressure, blood sugar level, temperature, weight, sleep disorders, epilepsy and heart rhythm.

The data can be used to check the health condition of residents with the remote monitor on distance. This is especially desirable for individuals with high health risk or those persons who are convalescing at home. In addition to monitoring people's social contact is important to the welfare of residents. Particularly, offering a visual connection with which residents can contact caregivers, family members and inmates can be a solution. This type of service is also strongly booming. Through a broadband connection contact is established with care providers and families, and the caregivers can see the medical history through an intranet.

Unlike home entertainment and automation devices, the healthcare and energy management devices are not in large-scale production. When looking at currently available healthcare devices we see that there are only few companies specialized in fabrication of these devices. Some of these care product vendors have defined their own certification standard, e.g. Continua (see appendix A).

Most of the healthcare devices use Bluetooth, USB or IEEE wireless technology, and are connected over IP protocol enabling data communication with a telemedicine access point. It also applies to most of the micro/nano- sensors, these devices use low power consumption technologies like Bluetooth, Zigbee or WiFi for short distance connectivity. ZigBee is already widely used in applications such as burglary protection, consumer electronics, telecommunications and intelligent energy systems.

### **6.3.4 Entertainment**

Over the last few years the multimedia and entertainment market is strongly growing. This growth is evident when looking at the wide range of digital cameras, computer games, home entertainment theatre systems, MP3 players, PDA's that are currently available in the market. In addition to individual product development there is also more and more services developed in this area.

The developments in the area of television-watching are very fast going. Think of the ever thinning of the screens and all the news about HD and 3D. One of the new innovations in this area is a television remote control, Samsung 9000, which is a remote with touchscreen that can view live images. The remote control allows for standard functions using infrared and WiFi for streaming images.

HDTV promises most significant improvement in quality since the introduction of colour TV. HDTV is offering up to five times sharper than regular TV. Manufacturers want to offer the best picture quality also on a disc. There are two successors to DVD: Blu-ray Disc and HD DVD. Most home cinema systems are incorporated with a set of five speakers and a subwoofer, which are connected to home theatre. The receiver, which places it between TV and a source (DVD, Blu-ray player, etc.) can enhance to surround sound and send it to the speakers. Furthermore, 3D-movies will spread out through the internet their resolution will be at least HD/eye. Currently, real convincing 3D-displays are still lacking but in the near future it will improve.

The Apple iPod, iPhone and iPad have rapidly conquered the world. Large music collections on CD suddenly became very accessible, and that irrespective of the place. Now it is also entered the home environment, and taking the place of cd players. Moreover, the iPad is replacing the bookshelves at home and functioning like an interface to the internet with more comfort. Apple has also introduced a completely revamped Apple TV. Its receiver unit is now a quarter of its original size and thus easily fits in palm of a hand. It has outputs for HDMI, digital audio, Ethernet and Wi-Fi, and up to 720p HD-content is supported. The new Apple TV Apple already made an emphasis on streaming content, because it doesn't have an internal hard disk. Furthermore, it can stream content from YouTube, Flickr, Netflix and MobileMe, a movie-TV-series service in the United States. This development shows that there will be more and more data traffic through the internet, with restricted requirements.

### 6.3.5 Home Automation

Home automation, also referred to as domotica represents electronic communications between all electrical appliances in the home and living environment for residents and service providers. In automated home activities like caring, communication, recreation and domestic activities become much easier by using numerous electrical devices and networks.

According to Verein Deutscher Ingenieur (VDI) the home automation is defined as: “Equipment, software and services for automatic control and regulation, monitoring and optimization as well as operation and management for the energy-efficient, economic and reliable operation of technical building services” [37]. Following fields can possibly be counted under home automation:

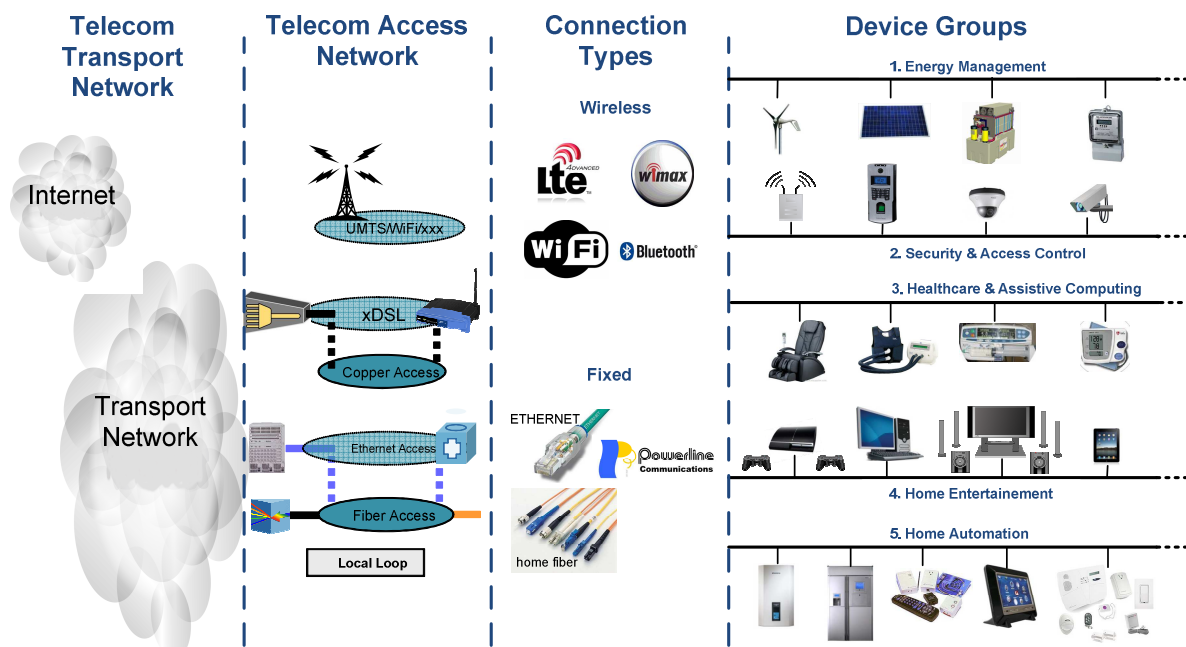
- Heating Ventilation Air Conditioning (HVAC): mechanical ventilation, air humidification, free convection heating/cooling
- Visual comfort: Artificial lighting, shading (motorized blinds/shutters)
- Safety: Fire alarm, gas alarm, water leak detection, emergency sound systems, emergency lighting, Closed Circuit Television (CCTV)
- Security: Intrusion alarm, access control, CCTV, guard tour patrol systems
- Communication technology: LAN, PBX (Private Branch Exchanges); voice intercom, public address/audio distribution and sound reinforcement systems
- Supply and disposal: Power distribution, fresh water, hot water, waste water, gas, switchgear, pumps
- Transport: Elevators, escalators, conveyor belts
- Special domains: Clock systems, flex time systems; AV systems (conference rooms, auditoriums; kitchen equipment, laundry/cleaning equipment)

One of the recent developments of home automation is Carebro, which enables people with disabilities, through the use of brain devices that operate in their environment and use their personal computer [38]. The control function is carried out by means of a sensor-controlled universal “household management”. This open-source system provides complete control of facilities in a residential installation. The originality of the innovation project Carebro is that the control of the platform is based on brain waves. The combination of care, self-help with the deployment of a household management system that is controlled by brain waves is unique for The Netherlands and the world.



## 6.4 Home network

The home network consists of access network, user network and in-home network, and the interconnection of these networks through the home gateway system.



**Figure 54: Overview of the network domains connecting the home**

Figure 54 illustrates the overview of the network domains connecting the home to the Telecom network. The device groups explained in the previous sections are connected either through wireless or fixed connections to the telecom access network.

### Residential Gateway

The Residential Gateway (RG) is the link between the local home network and a broadband internet connection via cable, xDSL, satellite or wireless (e.g. WiMAX). The term RG is used for the device or set of equipment that terminates the in-home network and takes care of indoor communication. It is a collection of functionalities like:

- connecting of in-home network with the access network, whereby in any communications layer the required transparency and protection are achieved for each service.
- is an always ‘on’ device, which has low power consumption. This allows all user devices in the home (including PCs) to be turned ‘off’ after use, but the in-home network remains ‘always online’, which will be needed for some services (e.g. peer-to-peer entertainment).
- plays the master role of the in-home network, so this function doesn’t have to be a subsidiary function of a user device (now often done by the computer, VCR or gaming device) with many disadvantages.
- can provide the necessary local storage functionality, so that TV images and other multimedia information can be stored. This can be the server of the in-home network;
- can have a platform that can be managed remotely.

The trend to integrate different functions into one central gateway has developed over the past few years. The best known development in this area is the integration of digital TV, Internet and telephony services into so-called Triple Play. The providers of these services often think of catchy names for these new Triple

Play Gateways. Additional to triple play gateways, it is expected that in the coming years they will be expanded with new functionalities which can be thought of energy management, security and automation. However, addition of these services to the residential gateway needs a powerful processor and specific middleware.

### **Home Network Middleware**

Middleware is a software layer that provides masking the heterogeneity of the underlying networks, hardware, operating systems and programming languages. It applies also to a programming abstraction. Since the market for residential gateways and associated middleware has been growing significantly in the past years, there are several new initiatives on this front.

Major home networking middleware includes: OSGi (Open Service Gateway initiative), UPnP (Universal Plug and Play), Jini, VESA (Video Electronics Standards Association), HAVi (Home Audio Video Interoperability), OpenCable, and DVB (Digital Video Broadcasting).

### **In-home connections**

To determining the necessary infrastructure for home networking, often the distinction is done between the following options:

- Networks using an existing infrastructure, such as the telephone or home electricity network;
- Networks that require a whole new infrastructure, such as the construction of a Unshielded Twisted Pair-cables (UTP) or fibre optic network inside home;
- Wireless networks – which is often easy to achieve in an existing home;

The most striking aspect when it comes to the development of the home network is that the technology over the past 10 years has prominently developed, but in terms of available infrastructure in new houses there are not many changes visible. Unfortunately, the new dwelling is the standardisation of in-home devices and network equipment. For example, a useful UTP network is lacking in virtually all new homes, which is actually needed for many applications.

**In-home standards**

Many different in-home related standards exist serving various purposes. Most of them are incompatible with each other. In Table 6 we see the great players in standardization of heterogeneous home systems. For an extended explanation see appendix E.3.

**Table 6: Overview Standardisation initiatives**

|        | Platform                     | Standards   | Physical communication media                                   | Members                    | Open/Not open   |
|--------|------------------------------|---|--|----------------------------|---|
| KNX    |                              | International, Canadian European, China Guo Biao - standard | Ethernet, Infrared, Radio(KNX-RF), Infrared, Twisted pair      | 160                        | Open  |
| UPnP   | Java, Linux, Mac OS, Windows | IP, TCP, UDP,HTTP, XML                                      | Ethernet, 802.11, Bluetooth                                    | More than 800              | Open  |
| DLNA   |                              | IP, TCP, UDP,HTTP   | Ethernet, 802.3i, 802.3u, Power line, 802.11(a/b/g), Bluetooth | 253                        | Not open, does not cover Apple devices, and no definitions for intercom devices   |
| G.hn   |                              |   | Phone line, Coax, Power line                                   |                            |   |
| X-10   |                              |   | Power line   |                            | Open  |
| Zigbee |                              |   | RF ISM bands 868 MHz (Europe), 915 MHz (USA)                   | more than 200              | No part of its specification may be used in development of a product for sale without becoming a member of ZigBee Alliance. |
| HGI    |                              | IMS, ITU, Broadband forum, DLNA and OSGi Allianc            | Ethernet, 802.11(a/b/g/n), USB 2.0, DECT, FXS, ISDN            |                            | Open  |
| MoCA   |                              |   | DOCSIS, VDSL, VDSL2 Wireless LAN, IEEE 802.11                  | 10 promoters, 98 associate | Not open, only one supplier of chipset  |

It is striking that some agencies do not open their solutions for everyone to use. DLNA, for example, does not support Apple and intercom equipment, which are currently the largest device suppliers.

Furthermore, ZigBee is a rapidly growing technology, but does not have specifications for everyone. An organisation must be member of this standard so that it may use Zigbee.

Moca is an RG solutions for cable operator, there is only one supplier for its chipset, and therefore it is not suited for telecom operators.

Open standards are comparable to industry standards: if the technology complies to the standard, we know definitely that it can easily fit the requirements of network operators or even the end-users, which also use the same standard. The in-home technology market is now dominated by default-standards developed by industry leaders, who are already busy with the development of the following default standard when potential suppliers are working to adapt to the previous default standard. This is obviously anti-competitive.

If open standards are defined in advance, then large and small market players simultaneously start to respond with creative products. Consequently, smaller players and R&D institutions can run off with these standards and requirements. Because everyone can use an open standard, the interchange ability between different types of hardware and software components increases.

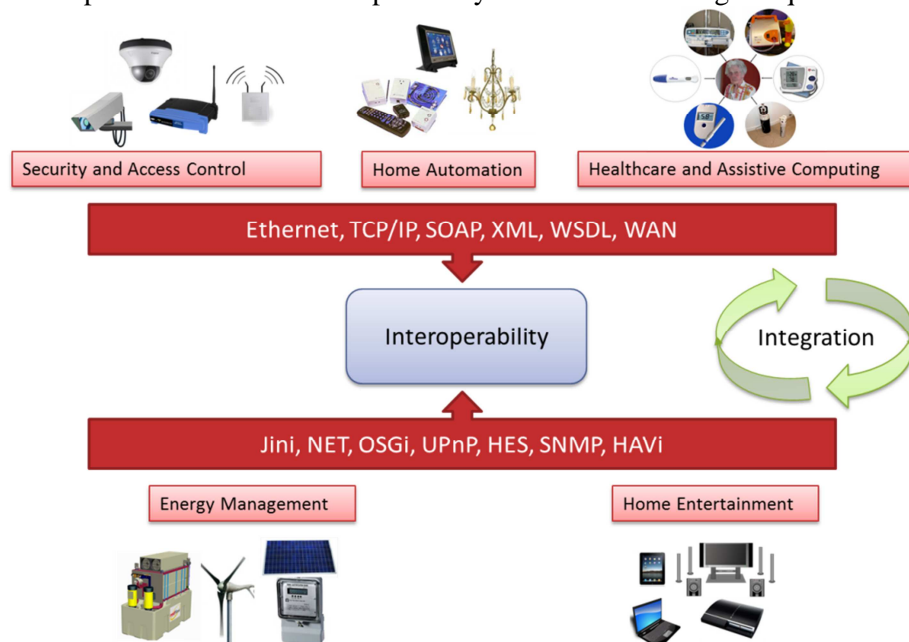
This could also create a greater diversity of providers, and they are less dependent on specific hardware and/or software, or any service provider. Therefore, developers can timely innovate cheaper and better products, and the leading parties stay dependent on these products.

The term “Open standard” is primarily used for hardware and software, because there are also too many non-open standards in use like mentioned above. Some examples of open standards are:

- Hardware: ISA, PCI, AGP
- Software: HTML/XHTML, SQL, IP, TCP, PDF, ODF, XMPP, HL7, LOM, SCORM

### Interoperability directions in-home standards

The ability of two or more systems or components to exchange information and use the information that has been exchanged is called interoperability. Interoperability in the context of digital technology generally relates to the situation that infrastructure equipment and software from different manufacturers using technical interfaces connect and collaborate with each other. Many heterogeneous systems are developed in isolation and independently without considering a requirement for interoperation.

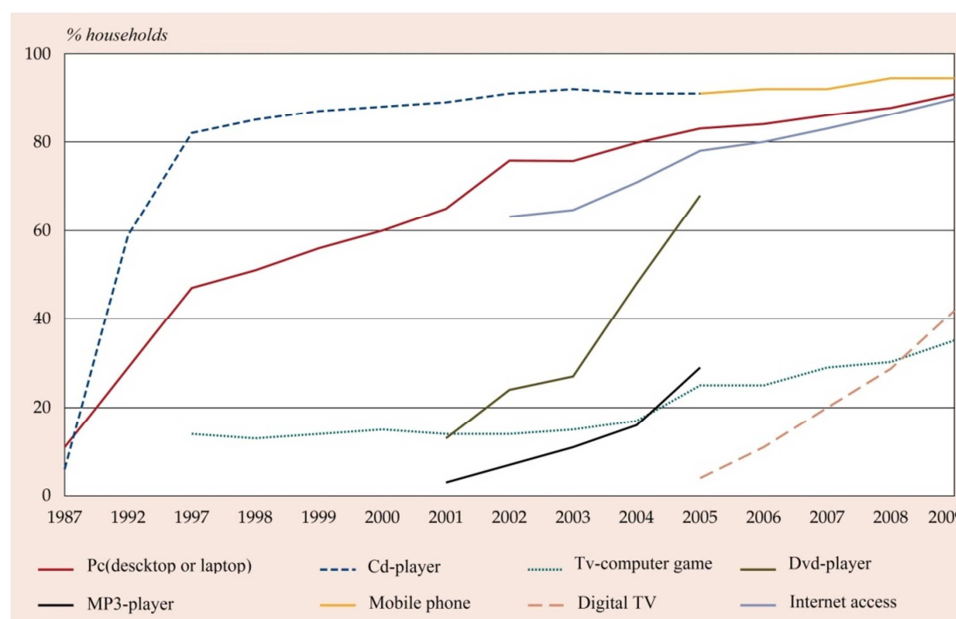


**Figure 55: Possible direction of convergence**

Figure 55 shows the possible direction of convergence of different home related standards. In the upper part three home device groups (Security and Access Control, Home Automation, Healthcare and Assistive Computing) are considered which are using IP related standards. However the lower part of Figure 55 shows the non-IP standardised device groups (Energy Management, Home Entertainment). Currently the last mentioned device groups are also starting to integrate IP based standards.

## 6.5 Trends in bandwidth growth and internet connectivity

Large bandwidth allows people to simultaneously use multiple computers, TVs and other multimedia devices to be online simultaneously without a hitch in the connection. High Speed Internet within a household makes it possible to watch HDTV, play online games, download music, and enjoy remote teaching making intensive use of the internet all at the same time. Researchers expect that an average household in 2011 needs an Internet connection to 50 Mbps downstream and 10 Mbps upstream (Itif, 2009). The volume of Internet traffic continues to rise and high-speed networks such as fibre optic networks are expanding rapidly. Connections of more than 50 Mbps make the Internet even more visual, for example, through HDTV. In addition, some high speed Internet communications capabilities continue to expand and allow consumers to contribute to the content of various websites using high upload speeds. In the future, not only individuals but also devices will be using the Internet. Home automation or home domotica, is a growing industry. The futuristic house is moving more and more into an environment that thinks with the resident about his or her duties and helps them in fulfilment. Lighting, heating, security, ventilation, telephone, and television cameras, for example, can work together to improve the quality of the living environment. As more devices will connect with the home network and the Internet, the need for greater bandwidth will also grow. In Figure 56 we see the trends of digital equipment's in a Dutch household from 1987 to 2009 provided by Statistics Netherlands (SN).

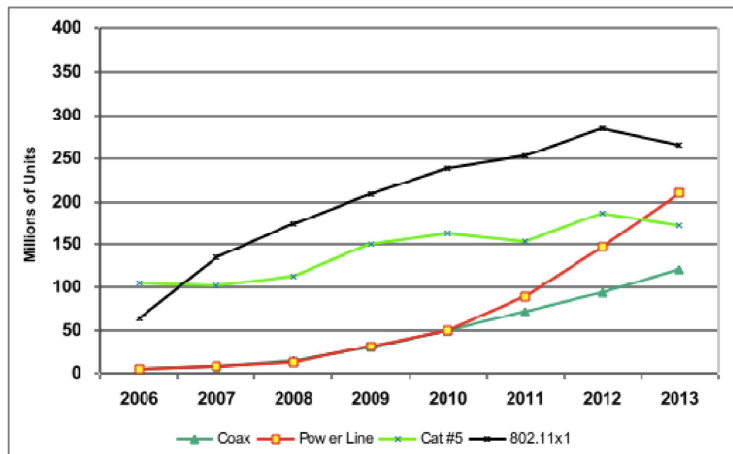


**Figure 56: Digital equipment in households (1987-2009) [39]**

The PC (laptop and desktop) is impossible to think away from Dutch households. Around the turn of the century, the PC ownership increased significantly and this trend keeps continuing. In 2002, over three quarters of households had a PC, in 2009 this increased to 91%. This trend is visible in Figure 56 Figure 56, which is concerned as nine over ten households of in total 6 million houses, which includes 12.1 million people. This brings the proportion of people with home access to a desktop or laptop in 2009 to 93%, while in 2002 it was just over 80%. Home Internet access is as obvious as the ownership of a PC. In Figure 56 we can also see that in 2009 internet access and PC ownership is at approximately the same level. There are very few PC owners who are not connected to the Internet.

Currently 80% of Dutch households have a broadband connection. This high penetration is partly due to a large scale rollout of telecom infrastructure, which makes the broadband internet available.

In The Netherlands, cable companies have broadband connections to nearly one third of Dutch households. The top three most growing ISP's in terms of subscribers includes Telfort, Alice and Ziggo. Ziggo is the largest Dutch ISP and the end of 2008 it counted 1.408 million customers. Next comes KPN 1.129 million DSL customers then UPC with 682,500 customers and finally HetNet the fourth ISP in The Netherlands.<sup>21</sup>



**Figure 57: Trends of communication carriers<sup>22</sup>**

In Figure 57 we see trends in communication carriers, which show that 802.11 Wi-Fi) is the most used technology for device communication, and it is ever growing until 2012. The managed home network need wired solutions. Wireless, such as WiFi, cannot meet the quality of service or the bandwidths necessary to support real-time multi-media traffic in the connected home. Because energy efficiency is going to be important criteria, the less efficient technology usage will be declined. However, powerline is more energy efficient than Wi-Fi, it only uses the powerline to send information through it.

<sup>21</sup> Dutch Broadband Q4 2008

<sup>22</sup> Source: iSuppli Wired Communications Q4'08 Topical Report

## 6.6 Conclusions from this chapter

There is currently no clear boundary emerge when a home is qualified to be called “Smart Home”. The innovation process that refines the functionality in the house and makes it more intelligent is a continuous process. We are moving into the age of the globally integrated and intelligent economy of society and planet. Therefore, there is a need to invest in substitution and modernization of the infrastructures. The PC is rapidly becoming just one out of a multitude of devices connected to the internet and consuming various services. A lot of electronics devices are already delivering new intelligence, and they all want to connect to each other. Those devices will be able to work collaboratively with other smart devices. It is essential to use innovation to create new business models and services for connected devices.

The current Internet provides a best effort quality. So to deliver high quality, high availability and high reliability a large-scale innovation is needed. And the main players here are the organizations from the Telecom sector, Manufacturing sector and the Government sector. Currently, the home’s inhabitants are system integrators facing increasing complexity. Making choices from the diversity of (defacto) standards is difficult because in today's liberalized market the interest of the various market parties in the standardization is an obstacle for collaboration. Each supplier (manufacturing), pushes his own solution toward users.

### **Many heterogeneous systems**

Within the Smart Home environment, there are many middleware and standards equipped with different communication protocols, which are enabled by heterogeneous systems. Managing these systems has been difficult and contributes towards rapid growth of residential gateways.

### **Interoperability**

Interoperability has traditionally been considered from an economic perspective, and it is all about providing access to markets through the availability of technical information and by eliminating any technical obstacles. This can be done in many ways, like acting in the standardization process or operating compatible with standards. Interoperability promotes the trade and stimulates the competition. Every market participant wishes to play on an equal level.

### **Coordination of service elements**

Some services will use several appliances; one example is video communication using TVs and telephones. Generally, users shouldn't be burdened with the task of setting up all their appliances to work together. Therefore, automatic coordination of the service element configuration is an important requirement for Service discovery and Device management.

### **Complexity of configurations**

Nowadays, due to the large number of solutions by different manufacturers, the complexity is increased in the installation interfaces, controlling of the sensors and the information exchange of various devices. Therefore, the development of these interfaces for suppliers is more valuable. And because each vendor makes his own equipment interfaces, the households have less freedom to choose for a particular (sub) system. The difficulties that home network has are to cope with: Tracking of network changes and Viability of device connectivity.

---

# 7. Conclusions

---

The Smart Living program aims to contribute to improve the Quality of Life of society and stimulate the good life [63]. The main challenge is balancing the limited available resources. Holon theory can help to understand the increasing complexities of current economic and societal problems.

On a macroscopic level, society and economy can be decomposed into roughly 20 sectors that together provide the foundations for our daily lives. Currently, a worldwide-accepted sector classification system does not exist. The Dutch activity classification “Standaard Bedrijfsindeling” (SBI) follows in aggregated level the International Standard Industrial Classification of All Economic Activities (ISIC), and has resulted in classification standards like SBI 1993 and SBI 2008. In SBI 2008, the branching of the activity cluster trees is less homogenous than SBI 1993. The data sets from Statistic Netherlands (SN) proved to be very useful for an exploratory look at the characteristics of the Sector Network from a Complex Network perspective studied at two levels. These are the sector network level and subordinate activity cluster level. Examination of link weights, the node weight and degree properties over time has shown and confirmed the discriminative character of vital sectors.

The number of people working in a sector is an example of node weight property associated with a specific sector. A related property is that the number of working people in Dutch Manufacturing decreased over time, while in the employment agencies this number has increased during the period 1993-2005. Another property of node weight of a sector is the internal monetary transaction being the diagonal post or diagonals.

The Dutch Ministry of Interior Affairs has identified 12 vital sectors of which 5 are commonly as a recognized section in ISIC. The vital part of the sector network comprises 21% of the corresponding activity cluster (22 of 105). Dependencies of vital sectors can be shown in a hierarchical graph. Furthermore, monetary transactions between all sectors are represented as a network, with nodes (activity clusters) and links (monetary transactions). When looking at the changes of connectivity of each node over time, a ranking of the vital sectors and their dependencies is realised. The results have shown that the vital sectors are the most densely connected nodes in these monetary networks. The four highest connected nodes are Energy, Telecom, Household and Finance. Moreover, it is discovered that when removing these highly connected nodes from the network, it becomes nearly disconnected. Furthermore, the Input Output table of SN is used to derive monetary trends looking at the changes that happened in both vital and non-vital sectors.

Expert interviews were carried out in order to identify and investigate the most important trends and new concepts concerning Telecom, Energy and Household sector. The households are increasingly taking a “prosumers” role in addition to their classical consumer role, and provide services to other sectors. The Telecom sector is an important enabler of these trans-sector innovations. The integration of ICT in the Energy sector is one of the examples, which is becoming increasingly interesting topic and governments and large numbers of enterprises are investing a lot of money in sustainability of the energy and its usage.



There is a clear need for fundamental innovation in the current Energy sector. Furthermore, the behaviour of energy consumers has to change, and infrastructure should be adapted to the transition to a sustainable energy system. The Smart Grid concept offers a solution for integration of sustainable energy sources in the future electricity system. Although Smart Grid is perceived differently by different parties, there are several aspects, which come back in many descriptions being listed as: Semi-autonomous, Optimization, Integration of distributed generation, Distributed control and Distributed generation

Smart Grids cover the set of solutions that make the home and neighbourhood energy-neutral, and help them to be independent of the central sources. An energy-neutral society would not rise so fast, but the current centralized systems will more and more adopt decentralized generation.

Finally, the research is narrowed down to the main in-home related developments. The different categories of in-home devices correspond to specific sectors that are connected to the household. Some of these sectors are physically connected to the home by means of their infrastructures e.g. the Energy, Telecom, Water and Transport. So the home can be seen as a holon connecting to other holons in the sector network (via their infra part). There are five device groups inside the home, from which two of them correspond to Energy and Healthcare sector. Generally there is no clear defined boundary between a home and a “Smart Home”.

To transform a typical contemporary home into a future Smart Home, the problems such as interoperability and complexity of the interior configurations have to be resolved. A lot of electronic devices already sophisticated with integrated intelligence and attempts to connect to other devices. Those devices will be able to work collaboratively with other smart devices. It is essential to use innovation to create new business models and services for connected devices.

### **Main conclusions:**

1. By considering the Household as a vital sector with regard to monetary transactions, it became the most connected vital sector with the largest amount of money containing and traversing it. Therefore, the household is nearly always participating in a trans-sector innovation.
2. The INFRA part of the Household sector contains a distributed infrastructure, and it has become vital because of its importance for people working at home, and people using online services regarding the following sectors: Healthcare, Energy, Finance, Education. Therefore, the most important infrastructures connected to household are the Energy and Telecom infra.
3. The SUPRA part of the Household sector, consist of intelligence, which helps to increase the quality of life and integrate services of other vital sectors to provide efficiency and sustainability. More sensors and devices are simplifying the living environment. Thereby, the household is shifting from production for own use, to vital functional element for society.

---

## 8. References

---

- [1] H. Wang, E. van Boven, A. Krishnakumar, M. Hosseini, H.van Hooff, T. Takema, N. Baken, P. Van Mieghem, “Characterizing Multi-weighted Networks: The Dutch Economy as a Monetary Transaction Network”, on-going research.
- [2] S. Popadiuka, C.W. Choob, “Innovation and knowledge creation: How are these concepts related?”, 2006.
- [3] C.S. Zúñiga, “Telecom sector modelling from a functional perspective”, MSc Thesis, July 2009.
- [4] N. Baken, N. van Belleghem, E. van Boven and A. de Korte, “Unravelling 21th Century Riddles, Network Visions from a Human Perspective”, The Journal of The Communication Network, London, Vol. 5, Part 4, 2006.
- [5] Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, “Informatie Vitale Sectoren”, July 2010.
- [6] United Nations Statistics Department, “The International Standard Industrial Classification of All Economic Activities, revision 4”, New York, 2008.
- [7] M. E. J. Newman, “The structure and function of complex networks”, 2003.
- [8] P. Vroon, “Tranen van de krokodil: over de snelle evolutie van onze hersenen”, 1989.
- [9] V. Frissen, M. Slot, “DE DUURZAME INFORMATIE SAMENLEVING”, chapter: “The art of Smart Living, een pleidooi voor transsectorale innovatie”, Nico Baken, 2010.
- [10] TRANS consortium, KPN, TNO, “Masterplan voor Smart Living”, on-going research.
- [11] G. Huitema, F. J. Rumph, “Leveraging Smart Energy Developments for Transsectoral Innovation”, November 2009.
- [12] Centraal Bureau voor de Statistiek, “Een input-outputtabel naar grootteklasse van de Nederlandse economie voor 1992: kleine, middelgrote en grote bedrijven”, 1997.
- [13] Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, “Beleidsbrief bescherming vitale infrastructuur”, September 2005.
- [14] Centraal Bureau voor de Statistiek, “De Nederlandse economie”, 2006.
- [15] Deloitte, “Revolutionaire evolutie: breedband in Nederland”, 2010.
- [16] IEA, “World Energy Outlook - China and India Insights”, 2007.
- [17] IEA, “World Energy Outlook”, 2008.
- [18] M. Arentsen, P. Hofman, P. Stapersma, “Literature Review on Innovation in Telecom, Automotive, Medical Technology and Copiers and Printers”, March 2007.
- [19] European Commission, “NETHERLANDS – Sustainable energy Fact Sheet”, January 2007.
- [20] Innovatie Platform, “Duurzame energie”, February 2010.
- [21] R.H. Lasseter, P. Piagi, “Microgrid: A Conceptual Solution”, June 2004.
- [22] R.H. Lasseter, Professor Emeritus, “Microgrids and Distributed Generation”, September 2007.
- [23] ECN, “PowerMatcher: een slimme technologie voor slimme netten”, March 2010.
- [24] W. Kempton, S. Letendre, Transportation Research: “Electric Vehicles as a New Source of Power for Electric Utilities”,(157-175), 1997.
- [25] C. W. Potter, “Building a Smarter Smart Grid Through Better Renewable Energy Information”, April 2009.

- [26] G. Papaefthymiou, A. Tsanakas, P. H. Schavemaker, L. van der Sluis, “Design of ‘Distributed’ Energy Systems Based on Probabilistic Analysis”, 2004.
- [27] T. Taylor, M. Ohrn, “Network management for Smart Grids”, March 2009.
- [28] L.M. Vaquero, L. Rodero-Merino, J. Cáceres, M. Lindner, ACM Computer Communication Reviews: “A Break in the Clouds: Towards a Cloud Definition”, January 2009.
- [29] S.H. Park et al., “Personal Ubiquitous computing: Smart home - digitally engineered domestic life”, 2003.
- [30] A. Fasbender et al., “Virtually at home: High performance access to personal media. Ericsson Review”, 2008.
- [31] A. Venkatesh, “Digital home technologies and transformation of households. Information systems frontiers”, 2008.
- [32] The Economist print edition, “Home, green home, in The Economist.”, 2008.
- [33] P. Bull, R. Limb, R. Payne, “BT Technology Journal: Pervasive Home environments.”, 2004.
- [34] T. Helbig, N. Tan, “A window on the connected world. Philips research password”, 2003.
- [35] F.K. Aldrich, “Smart homes: past, present and future. In: Harper R (ed) Inside the smart home”, 2003.
- [36] D. Gann, J. Barlow, T. Venables, “Digital futures - Making homes smarter” 1999.
- [37] www.vdi.eu, “VDI-Richtlinienausschuss 3814”, 2007.
- [38] www.negotica.net, “Negotica development projects”, 2009.
- [39] Centraal Bureau voor de Statistiek, “De digitale economie”, 2009.
- [40] www.femtoforum.org, “Femto Forum”, 2009.
- [41] ABI Research, “Femtocell Access Points: Fixed-Mobile Convergence for Residential, SMB, and Enterprise Markets”, 2009.
- [42] The Engineering Handbook of Smart Technology for Aging, Disability, and Independence
- [43] N. Papadopoulos, A. Meliones, D. Economou, I. Karras, I. Liverezas , “A Connected Home Platform and Development Framework for Smart Home Control Applications”, 2009.
- [44] C.Y. Chen, Y. P. Tsou, S. C. Liao, C. T. Lin, “Implementing the Design of Smart Home and Achieving Energy Conservation”, 2008.
- [45] www.knx.org, “KNX Association – its activities”, 2007.
- [46] Echelon Corporation, “LonWorks at Work in Buildings Around the World”, June 2009.
- [47] S.C. Ergen, “ZigBee/IEEE 802.15.4 Summary”, September 2004.
- [48] www.zigbee.org, “ZigBee Wireless Sensor Applications for Health, Wellness and Fitness”, March 2009.
- [49] A. Koestler, “The Ghost in the Machine.” Macmillan Company, 1967.
- [50] C.H. Fu, Z.P. Zhang, H. Chang, J.R. Tao, Z.H. Chen, Y.L. Dai, W. Zhang, D.R. Hea, “A kind of collaboration–competition networks”, October 2007.
- [51] NIST, “Framework and Roadmap for Smart Grid Interoperability Standards Release 1.0 (Draft)”, September 2009.
- [52] M. Valero, L. Vadillo, I. Pau, A. Peñhalver , “An implementation framework for smart home telecare services”, 2009.
- [53] Sociaal-Economische Raad, “Duurzame globalisering: een wereld te winnen”, June 2008
- [54] Adriaan Borst-Fonds, “Juryrapport Adriaan Borstprijz 2008 voor Mgr. A.H. (Ad) van Luyn s.b.”, 2008.
- [55] N. Baken, E. van Boven, B. Feunekes, S. Mesgarzadeh “Trusted transactions transforming your life”, 2008.
- [56] Ministerie van Economische Zaken, “Energierapport”, 2008.
- [57] A. Helal, M. Mokhtari, B. Abdulrazak, “The Engineering Handbook of Smart Technology for Aging, Disability, and Independence”, January 2008.
- [58] Centraal Bureau voor de Statistiek, “Standaard Bedrijfsindeling SBI 1993”, January 1994.
- [59] Centraal Bureau voor de Statistiek, “Standaard Bedrijfsindeling SBI 2008”, January 2009.

- [60] A. Vaccaro, M. Popov, D. Villacci, V. Terzija, “An Integrated Framework for Smart Microgrids Modelling, Monitoring, Control, Communication and Verification”, on-going research.
- [61] Euro RSCG: “Prosumer Pulse 2004: A Global Study-Anticipating Consumer Demand”, 2004.
- [62] A. Toffler, “The Third Wave”, 1980.
- [63] P. Hadot, “Oefeningen van de geest”, 2005.
- [65] IEC, “Smart Grid Standardization Roadmap”, June 2010.
- [66] K. Twaite, “Monopoly money: reaping the economic and environmental benefits of microgrids in exclusive utility service territories”, 2010
- [67] R. Murray, G. Mulgan, J. Caulier-Grice, The Young Foundation, “How to Innovate: The tools for social innovation”, February 2010

# Appendices

## A Inventory

**Table 7: Inventory of related projects**

|                                      | Initiatives   | Description   | Organizations              |
|--------------------------------------|---|---|----------------------------|
| <b>Smart Living related projects</b> |   |   |                            |
| <b>1</b>                             | Smart Living<br>2009 – 2020<br><br>Pilot project is started with 500 houses.<br>Amsterdam | On a humanised scale, using decentralized (local) organization strength, trans-sector collaboration on sustainable completion of basic needs that are already apparent in the residential environment.  | TNO, IBM, Eneco, AIM, KPN  |
| <b>2</b>                             | Digital Home SIG  | The FMCA is a global organisation (2004). The scoop of Digital Home SIG is offering services and implementation models of Digital Home. Also the architecture, use cases, scenarios and requirements for converged devices and home networking technologies are considered.   | FMCA                       |
| <b>3</b>                             | ICTRegie: IIP-DSL<br>2009 - e.v.<br><br>NL  | The companies and institutions who were already united in the Domotica Platform initiate the IIP Domotica & Smart Living. This platform investigates new possibilities for improvements of the quality of life, the productivity of households and the value of living environment.   | TU-Delft, TNO, KPN, Others |
| <b>4</b>                             | B@Home<br>2004 - 2008   | The project B@Home aims to develop new business models and technical architectures for end-to-end provision of ubiquitous broadband services to the home, supporting people with their needs for infotainment, health care, education and work.   | Freeband                   |
| <b>Smart Grids related projects</b>  |   |   |                            |
| <b>5</b>                             | Smart City Project<br>2009 - e.v.<br><br>The pilot project is running.<br>Amsterdam       | This is a pilot project to help 500 Amsterdam households cut energy bills and reduce CO2 emissions. Cisco provides an IP-based home energy management system, with energy display that link to appliances and other power-using systems within the home, e.g. smart meters provided by Nuon, through both WiFi and powerline carrier communications network. IBM provides the applications, the energy management system and links them to the data centres to be stored. | Cisco, IBM, Nuon           |

|                                    |   |   |  |
|------------------------------------|---|---|--|
| <b>6</b>                           | The SmartHouse/Smart Grid project 2008 – 2011 Execution phase, already funded (2.56mln) in GR, NL and DE. | ICT-enabled collaborative technical-commercial aggregations of Smart Houses, to achieve the needed radically higher levels of energy efficiency in Europe.  | PCC, ECN, ICCS, MVV ENERGIE AG, ISET                               |
| <b>8</b>                           | NIST: Smart Grid Interoperability Standards Project   | Under EISA, primary responsibility to coordinate development of a framework that includes protocols and model standards for information management to achieve interoperability of Smart Grid devices and systems  | ESIA   |
| <b>9</b>                           | ERANET 2007 Europe  | Cooperation / Harmonization national research program in context of Smart Grids in Europe, also Netherland is participating.  |  |
| <b>Healthcare related projects</b> |   |   |  |
| <b>10</b>                          | The UAS system 2001 – 2008 NL   | A security system developed for healthcare. It is used in nursing to alerts the nurses when patients are in danger.   | TNO  |
| <b>11</b>                          | Motiva thuiszorg system 2007 – 2014 The pilot project is finished, working on large scale deployment.     | To increasing the self-reliance of chronic patients, so their quality of life improves and decreases hospital visits. The first pilot project was started June 2009 and took 12 months, in this pilot project a group of 630 chronic heart patients of 8 hospitals in Rotterdam are participating. Philips’ Motiva is an interactive system to help patients receive home care, send up their data with broadband technologies. | Philips, Achmea  |
| <b>12</b>                          | Koala 2006 - 2007 Low scale deployed, working on large scale deployment. NL                               | Koala is a bridge between small-scale pilot projects that often cover one aspect of technological possibilities, and it aims a wide range of new care services. The ultimate goal is to optimize the care and welfare of people with chronic disease and elderly.   | Thuiszorg Groningen, Menzis, KPN, Meavita                          |
| <b>13</b>                          | Pilot personen alarmering plus 2005 – 2006 Completed in Amsterdam   | This pilot project extensively tested the personal alarming system, with automatic data transport from sensors and used devices like: wireless sender, smoke detectors, infrared reporter, electronic door lock, light comfort system.  | CareWestOsira Groep, Het Oosten, de Algemene Woningbouw Vereniging |
| <b>14</b>                          | Tele-ECT 2005 e.v.<br><br>Already in use in NL, also outside NL.  | Tele-ECT is a small device to make an ECG that can be forwarded with a mobile phone, to be used for diagnosing and monitoring. It mainly uses Bluetooth and GPRS technologies.  | Life Signal  |

|                           |   |  |  |
|---------------------------|---|--|--|
| <b>15</b>                 | Zorg in Beeld<br>2007 – 2008<br><br>First delivery already in use.<br>Dordrecht   | The aim of this project is to help residents to live independently, by delivering remote care the feeling of safety. It consist of personal alarm system, fire alarm and video intercom systems: application of the multifunction home automation system for housing and care of the second generation Vicasa. | Simac,<br>Progrez,<br>Internos<br>Thuiszorg,<br>Stichting<br>Het Spectrum,<br>Thureborgh |
| <b>16</b>                 | Zorgstation<br>Parkwijk<br><br>2005 e.v.<br>Utrecht   | The deployment of a wireless system consisting of video contact and touch screen, that allows customers to make contact with care workers and to live secure and independently.  | Zorgstation<br>Parkwijk,<br>Aveant   |
| <b>17</b>                 | Domotica / Zorg-<br>op-afstand project<br>Zorgpalet<br>Baarn/Soest<br>2008 - 2009<br>This project is the pre-production pilot. System is already in de market.<br>Utrecht | The aim of this project is enhancing safety for clients living at home having nursing home indication and receiving nursing at home. It targets people with dementia (late stage) and those with somatic complaints. This application development system is based on the ambient intelligent technology: UAS   | Vilans,<br>Zorgpalet<br>Baarn, Soest,<br>TNO Defensie en Veiligheid                      |
| <b>Converged Platform</b> |   |  |  |
| <b>18</b>                 | Project “Y”<br>2005 – 2007<br>in NL   | The aim of this project is to optimise and enhance the Service Architecture of the KPN. The project has contributed to introduction of IMS within KPN network.   | KPN  |
| <b>19</b>                 | NG HLR<br>2009 - 2011<br>Project is in the implementation phase in NL.  | The aim of this project is de convergence of the HLR (user database for cellular networks, e.g. GSM, UMTS, GPRS) and HSS (user database used for fixed and future LTE network).  | KPN  |

## B Classification systems and their relations

The SBI 1993 is based on the classification of the European Union, Nomenclature statistique des Activités économiques dans la Communauté Européenne (NACE) and that of the United Nations, International Standard Industrial Classification of All Economic Activities (ISIC). SBI 1993 has six levels, with the two highest levels (sections and subsections) indicated by letters and the lower levels (divisions, groups, classes and subclasses) which are indicated by numbers.

SBI-code to the level of classes (four digits) is similar to the NACE, which is applied in all EU Member States. The subclass level, indicated by 5 digits, is a more specific case for Dutch classification. At the level of division, indicated by two digits according to SBI 1993 and NACE which also corresponds to ISIC of the United Nations.

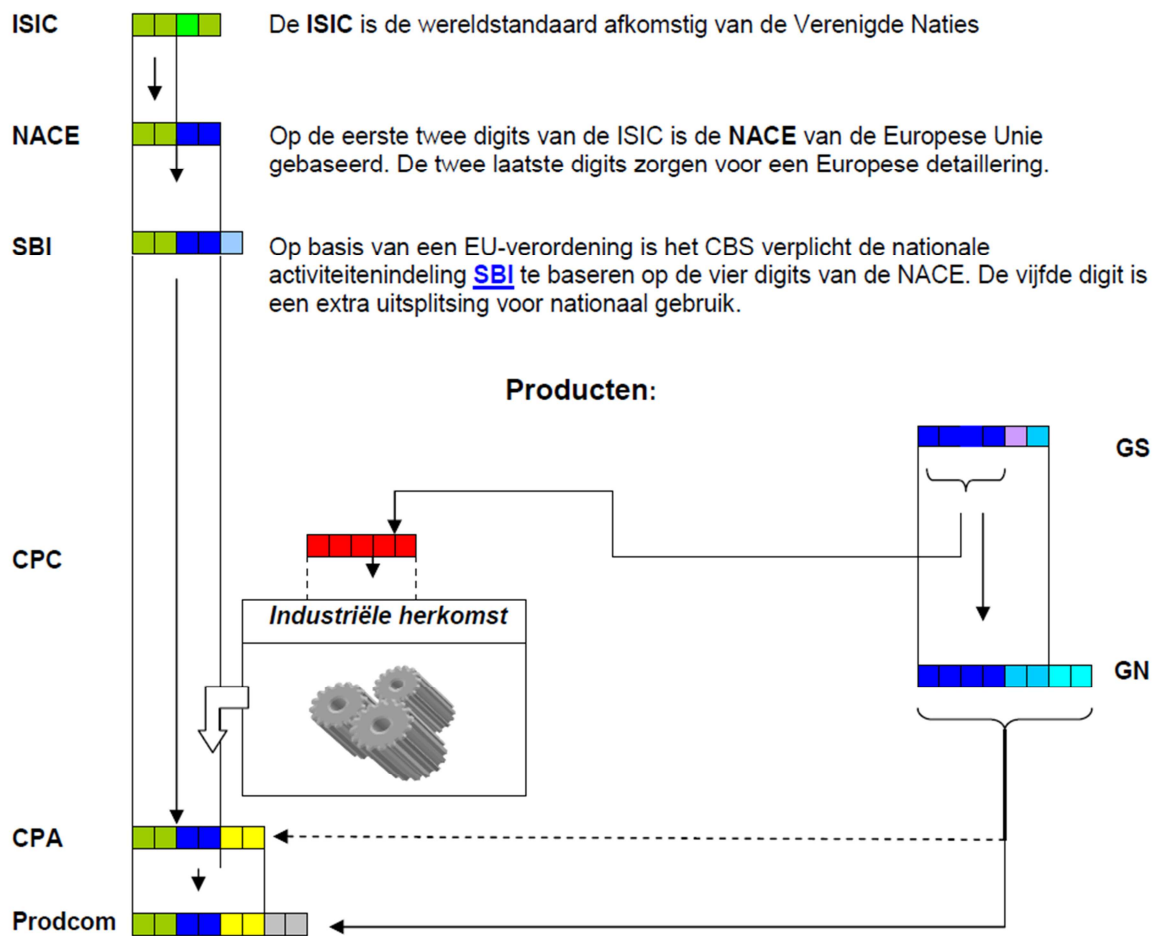


Figure 58: SBI distraction [6]



**Table 8: Mapping sections (SBI 1993), sectors and Input Output table**

| Section | Sector        |    | Activity cluster (I/O)   | Vital |
|---------|---------------|----|--|-------|
| A       | Agriculture   | 1  | arable farming   |       |
|         |               | 2  | market gardening   |       |
|         |               | 3  | animal production  |       |
|         |               | 4  | other agriculture  |       |
|         |               | 5  | gardening and agriculture specific services                                      |       |
|         |               | 6  | forestry and hunting   |       |
| B       |               | 7  | fishing and aquaculture  |       |
| C       | Mining        | 8  | extraction of oil and natural gas  |       |
|         |               | 9  | mining other resources   |       |
| D       | Manufacturing | 10 | processing and preserving meat   |       |
|         |               | 11 | processing and preserving crustaceans and mollusc                                |       |
|         |               | 12 | processing and preserving of fruit and vegetables                                |       |
|         |               | 13 | manufacture of dairy products  |       |
|         |               | 14 | manufacture of prepared animal feeds   |       |
|         |               | 15 | manufacture of other food products n.e.c.  |       |
|         |               | 16 | manufacture of coffee and tea  |       |
|         |               | 17 | manufacture of beverages   |       |
|         |               | 18 | manufacture of tobacco products  |       |
|         |               | 19 | manufacture of textiles  |       |
|         |               | 20 | manufacture of confection  |       |
|         |               | 21 | manufacture of leather and related products                                      |       |
|         |               | 22 | manufacture of wood, cork and plaiting materials                                 |       |
|         |               | 23 | manufacture of pulp, paper and paperboard  |       |
|         |               | 24 | manufacture of corrugated paper, paperboard & containers of paper and paperboard |       |
|         |               | 25 | publishing and printing  |       |
|         |               | 26 | reproduction of recorded media   |       |
|         |               | 27 | processing of coke and renewed petroleum products                                |       |
|         |               | 28 | manufacture of basic chemicals   |       |
|         |               | 29 | manufacture of anorganic chemical products                                       |       |
|         |               | 30 | manufacture of renewed petroleum products  |       |
|         |               | 31 | manufacture of fertilisers and nitrogen products                                 |       |
|         |               | 32 | manufacture of chemical end products   |       |
|         |               | 33 | manufacture of rubber, synthetic rubber and plastic products                     |       |
|         |               | 34 | manufacture of construction materials  |       |
|         |               | 35 | manufacture of basic metals  |       |
|         |               | 36 | manufacture metal products   |       |
|         |               | 37 | manufacture of machinery and equipment   |       |
|         |               | 38 | manufacture of household related machinery and equipment                         |       |

| Section | Sector           |    | Activity cluster (I/O)  | Vital |
|---------|------------------|----|---|-------|
|         |                  | 39 | manufacture of machinery and computers                          |       |
|         |                  | 40 | manufacture of other electrical machinery and equipment         |       |
|         |                  | 41 | manufacture of audio, video and telecommunications equipment    |       |
|         |                  | 42 | manufacture of medical, measure and control equipment           |       |
|         |                  | 43 | manufacture of motor vehicles                                   |       |
|         |                  | 44 | manufacture of ships  |       |
|         |                  | 45 | manufacture of railway, aircraft and aerospace related vehicles |       |
|         |                  | 46 | manufacture other transport means                               |       |
|         |                  | 47 | manufacture of furniture  |       |
|         |                  | 48 | other manufacture of goods n.e.c.                               |       |
|         |                  | 49 | recycling preparation   |       |
| E       | Energy           | 50 | electricity, gas, steam and air conditioning supply             | V     |
|         | Water            | 51 | water collection and distribution                               | V     |
| F       | Construction     | 52 | site preparation  |       |
|         |                  | 53 | construction of buildings                                       |       |
|         |                  | 54 | construction of roads, railways and water projects              |       |
|         |                  | 55 | building installation   |       |
|         |                  | 56 | building completion   |       |
|         |                  | 57 | renting construction machines                                   |       |
| G       | Trade            | 58 | motor vehicles wholesale trade                                  |       |
|         |                  | 59 | motor vehicles retail trade                                     |       |
|         |                  | 60 | car service and gas stations                                    |       |
|         |                  | 61 | wholesale trade   | V     |
|         |                  | 62 | retail trade  | V     |
| H       | Horeca           | 63 | accommodation and food service activities                       |       |
| I       | Transport        | 64 | public transport  | V     |
|         |                  | 65 | transport of goods  | V     |
|         |                  | 66 | transport via pipelines   | V     |
|         |                  | 67 | sea transport   | V     |
|         |                  | 68 | river transport   | V     |
|         |                  | 69 | air transport   | V     |
|         |                  | 70 | services for land transport                                     | V     |
|         |                  | 71 | services for water transport                                    | V     |
|         |                  | 72 | services for air transport                                      | V     |
|         |                  | 73 | travel agencies   |       |
| I       | Telecom and post | 74 | post and telecommunications                                     |       |
| J       | Finance          | 75 | banking   | V     |
|         |                  | 76 | insurance   | V     |
|         |                  | 77 | financial support companies                                     |       |
| K       | Real Estate      | 78 | real estate exploitation  |       |
|         |                  | 79 | other real estate   |       |

| Section | Sector     |     | Activity cluster (I/O)  | Vital |
|---------|------------|-----|---|-------|
|         |            | 80  | renting mobile goods  |       |
|         |            | 81  | computer services   |       |
|         |            | 82  | research  |       |
|         |            | 83  | legal consultancy   |       |
|         |            | 84  | engineers and architects  |       |
|         |            | 85  | advertisement and promotion companies                             |       |
|         |            | 86  | labour recruitment and provisional of personnel                   |       |
|         |            | 87  | cleaning of buildings   |       |
|         |            | 88  | other business services   |       |
| L       | Government | 89  | common central government administration                          | V     |
|         |            | 90  | common decentralised government administration and municipalities |       |
|         |            | 91  | other government administration and social insurances             | V     |
|         |            | 92  | defence   | V     |
| M       | Education  | 93  | primary education   |       |
|         |            | 94  | secondary education   |       |
|         |            | 95  | tertiary education  |       |
| N       | Healthcare | 96  | medical services  | V     |
|         |            | 97  | care for well-being   |       |
|         |            | 98  | private companies environmental care                              |       |
| O       |            | 99  | governmental environmental care                                   |       |
|         |            | 100 | culture, sports, recreation, radio and television                 |       |
|         |            | 101 | gambling  |       |
|         |            | 102 | other services  |       |
| P       |            | 103 | household services  |       |
| O       |            | 104 | goods and services n.e.c.   |       |
|         |            | 105 | Household spending and salaries <sup>23</sup>                     | V     |

<sup>23</sup> In I/O table the activity cluster 105 is not taken into account. The activity cluster 105 Household is a special node which is added in this table for the research purposes explained in subparagraph 3.2.2. This node is essential for our research to consider the household as an important node in the monetary network analysis.

Table 9: Ranking of connectivity vital activity clusters links  $\geq 1$  mln

| 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |  |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|--|
| 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  |  |
| 61   | 61   | 61   | 61   | 61   | 61   | 61   | 61   | 61   | 61   | 61   | 61   | 61   | 61   | 61   |  |
| 50   | 50   | 74   | 74   | 74   | 74   | 74   | 74   | 74   | 74   | 74   | 74   | 74   | 74   | 74   |  |
| 75   | 74   | 50   | 50   | 50   | 50   | 50   | 50   | 50   | 50   | 50   | 50   | 50   | 96   | 50   |  |
| 74   | 96   | 90   | 96   | 96   | 75   | 75   | 75   | 96   | 96   | 96   | 96   | 96   | 50   | 96   |  |
| 96   | 75   | 96   | 75   | 75   | 96   | 96   | 96   | 75   | 75   | 75   | 75   | 75   | 75   | 75   |  |
| 90   | 90   | 75   | 90   | 89   | 90   | 90   | 89   | 89   | 90   | 89   | 90   | 90   | 90   | 90   |  |
| 64   | 64   | 64   | 65   | 65   | 65   | 65   | 65   | 65   | 65   | 65   | 65   | 65   | 65   | 65   |  |
| 51   | 51   | 51   | 51   | 51   | 51   | 51   | 51   | 51   | 51   | 51   | 51   | 51   | 51   | 51   |  |

Table 10: Ranking of connectivity vital activity clusters links  $\geq 10$  mln


| 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |  |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|--|
| 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  |  |
| 61   | 61   | 61   | 61   | 61   | 61   | 61   | 61   | 61   | 61   | 61   | 61   | 75   | 61   | 61   |  |
| 75   | 75   | 75   | 75   | 75   | 50   | 50   | 50   | 50   | 50   | 50   | 75   | 61   | 50   | 50   |  |
| 50   | 50   | 50   | 50   | 50   | 75   | 75   | 75   | 75   | 75   | 75   | 50   | 50   | 75   | 75   |  |
| 74   | 74   | 74   | 74   | 74   | 74   | 74   | 74   | 74   | 74   | 74   | 74   | 74   | 74   | 74   |  |
| 90   | 90   | 96   | 96   | 96   | 96   | 96   | 96   | 96   | 96   | 96   | 90   | 90   | 96   | 96   |  |
| 96   | 96   | 90   | 90   | 90   | 90   | 90   | 90   | 90   | 90   | 90   | 96   | 96   | 90   | 90   |  |
| 64   | 64   | 64   | 64   | 65   | 65   | 65   | 65   | 65   | 65   | 65   | 65   | 65   | 65   | 65   |  |
| 51   | 51   | 51   | 51   | 51   | 51   | 51   | 51   | 51   | 51   | 51   | 51   | 51   | 51   | 51   |  |

Table 11: Ranking of connectivity vital activity clusters links  $\geq 100$  mln

| 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |  |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|--|
| 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  |  |
| 61   | 75   | 75   | 75   | 75   | 75   | 75   | 75   | 75   | 75   | 75   | 75   | 75   | 75   | 75   |  |
| 75   | 61   | 61   | 61   | 61   | 61   | 61   | 61   | 61   | 61   | 74   | 74   | 50   | 50   | 50   |  |
| 50   | 50   | 50   | 50   | 74   | 74   | 74   | 74   | 74   | 74   | 61   | 61   | 74   | 74   | 74   |  |
| 74   | 74   | 74   | 74   | 50   | 50   | 50   | 50   | 50   | 50   | 50   | 50   | 61   | 61   | 61   |  |
| 90   | 90   | 90   | 90   | 90   | 90   | 89   | 89   | 90   | 89   | 90   | 90   | 90   | 90   | 90   |  |
| 96   | 96   | 96   | 96   | 96   | 96   | 96   | 96   | 96   | 96   | 96   | 96   | 96   | 96   | 96   |  |
| 69   | 69   | 69   | 65   | 65   | 65   | 65   | 65   | 65   | 70   | 65   | 65   | 70   | 65   | 70   |  |
| 51   | 51   | 51   | 51   | 51   | 51   | 51   | 51   | 51   | 51   | 51   | 51   | 51   | 51   | 51   |  |


**Table 12: Ranking of connectivity vital activity clusters links  $\geq 1000$  mln**

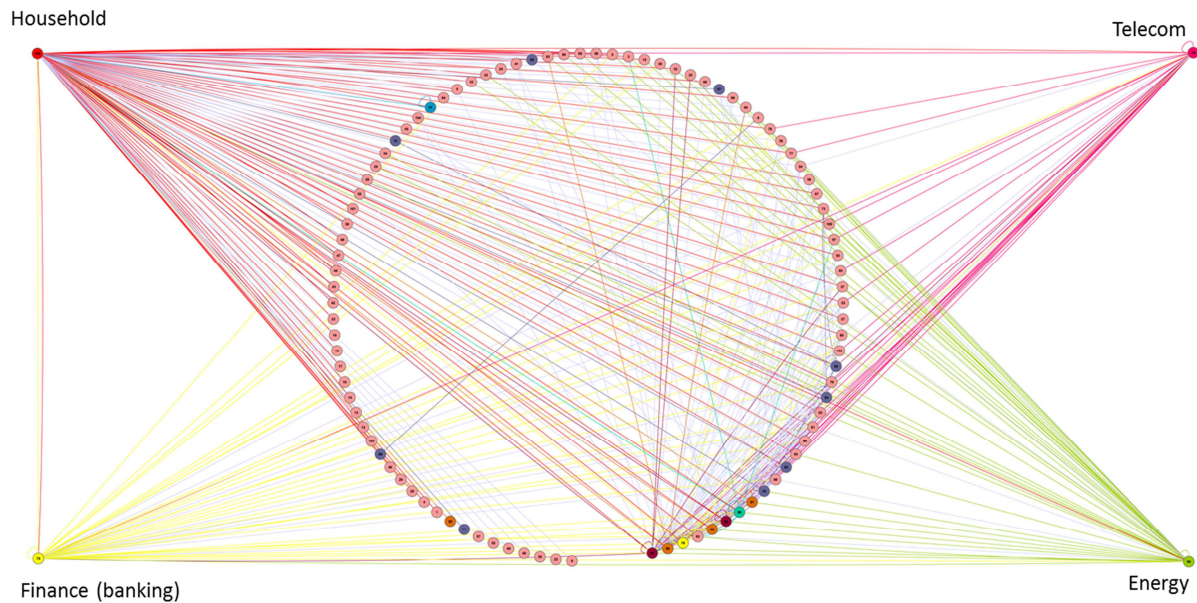
| 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  |
| 50   | 50   | 50   | 75   | 50   | 50   | 75   | 75   | 75   | 61   | 61   | 61   | 75   | 75   | 61   |
| 75   | 75   | 75   | 50   | 75   | 75   | 50   | 74   | 74   | 74   | 74   | 75   | 61   | 50   | 75   |
| 96   | 96   | 96   | 96   | 96   | 96   | 74   | 61   | 61   | 75   | 75   | 74   | 74   | 61   | 50   |
| 90   | 90   | 90   | 90   | 90   | 90   | 96   | 50   | 50   | 50   | 50   | 90   | 50   | 74   | 74   |
| 74   | 74   | 74   | 74   | 74   | 61   | 90   | 90   | 90   | 90   | 90   | 50   | 90   | 90   | 90   |
| 64   | 64   | 64   | 64   | 64   | 74   | 61   | 96   | 96   | 96   | 96   | 96   | 96   | 96   | 96   |
| 62   | 62   | 62   | 62   | 62   | 64   | 64   | 64   | 64   | 64   | 64   | 64   | 69   | 69   | 69   |



**Table 13: Ranking of connectivity vital activity clusters links  $\geq 10000$  mln**

| 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  | 105  |
| 61   | 61   | 61   | 61   | 61   | 61   | 61   | 61   | 61   | 61   | 61   | 61   | 61   | 61   | 61   |
|      |      |      |      |      |      |      | 76   | 76   | 76   | 76   | 76   | 76   | 76   | 76   |
|      |      |      |      |      |      |      |      |      | 96   | 96   | 96   | 96   | 96   | 96   |





**Figure 59: Top 4 highest degree activity clusters (Link weight  $\geq 100$  mln)**

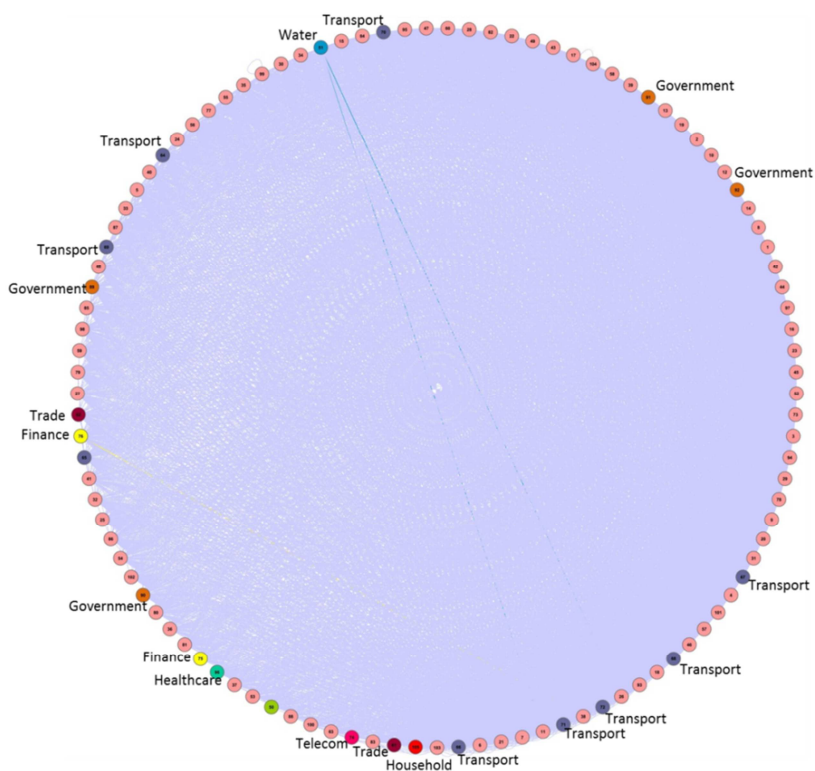
**Non-existing connections within the I/O network**

**Link weight = 0 mln**

Within the data set of I/O, nearly the half of the elements (of total 105x105) corresponds to an empty or a zero element. However an empty element means non-existing relation and a zero means rounded down to zero. In Figure 60 both are considered as non-existing links.

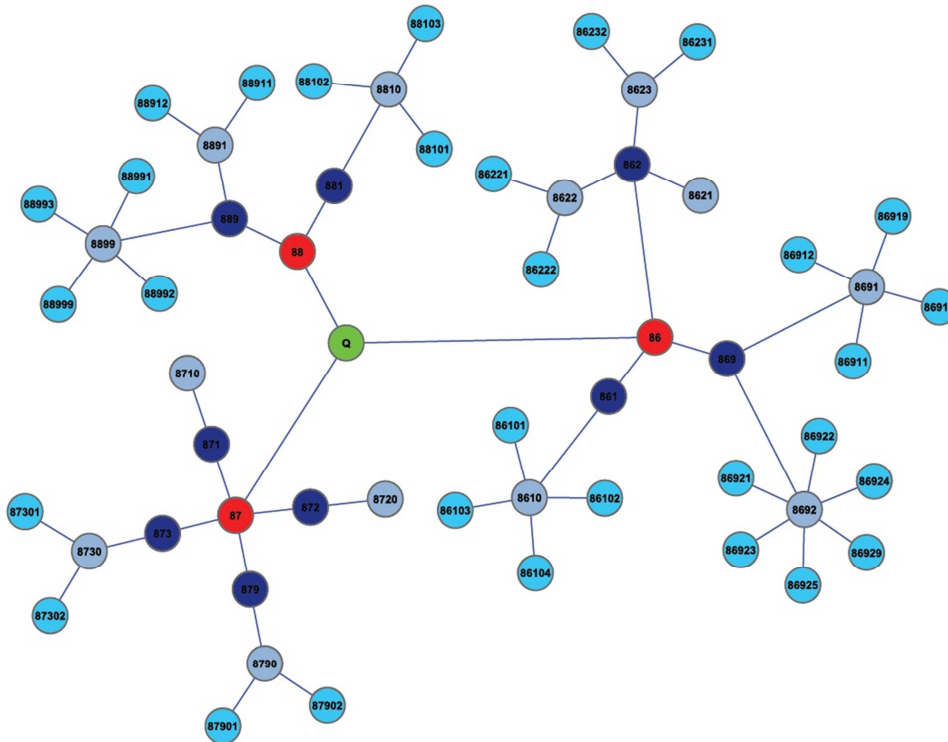
Because the sector network is very dense in nature, we also plot the non-existing links between the 105 activity clusters. Figure 60 shows the non-existing links of the transaction network of 2007. Household has the lowest connectivity degree in this graph.

Nodecount = 105  
Linkcount = 5307



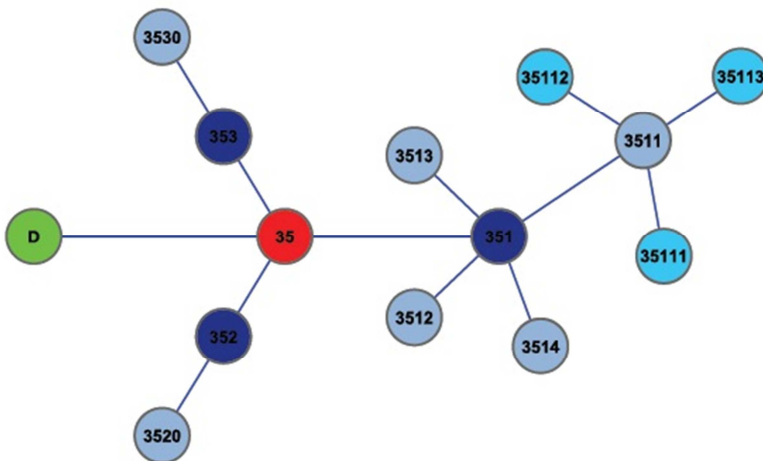
**Figure 60: Money transaction network 2007 (Link weight = 0 mln)**

**Some activity cluster structure examples**



**Figure 61: The SBI 2008 structure of Healthcare (section Q)**

Figure 61 shows an example of section Q derived from the SBI 2008 tree structure, represented as a planar graph.



**Figure 62: The SBI 2008 structure of Energy (section D)**

Figure 62 shows a second example of a planer graph which represents the section D of SBI 2008 classification.

## C Trend analysis

| Sector                              | Product of dienst   |
|-------------------------------------|---|
| 1 Energie                           | 1 Elektriciteit   |
|                                     | 2 Aardgas   |
|                                     | 3 Olie  |
| 2 Telecommunicatie                  | 4 Vaste telecommunicatievoorziening   |
|                                     | 5 Mobiele telecommunicatievoorziening   |
|                                     | 6 Radiocommunicatie en navigatie  |
|                                     | 7 Satellietcommunicatie   |
|                                     | 8 Omroep  |
|                                     | 9 Internet-toegang  |
|                                     | 10 Post- en koeriersdiensten  |
|                                     | 11 Drinkwatervoorziening  |
| 3 Drinkwater                        | 12 Voedselvoorziening/ -veiligheid  |
| 4 Voedsel                           | 13 Spoedeisende zorg/overige ziekenhuiszorg                                   |
| 5 Gezondheid                        | 14 Geneesmiddelen   |
|                                     | 15 Sera en vaccins  |
|                                     | 16 Nucleaire geneeskunde  |
| 6 Financieel                        | 17 Betalingsdiensten / betalingstructuur                                      |
|                                     | 18 Financiële overdracht overheid   |
| 7 Keren en beheren oppervlaktewater | 19 Beheren waterkwaliteit   |
|                                     | 20 Keren en beheren waterkwantiteit   |
| 8 Openbare Orde en Veiligheid (OOV) | 21 Handhaving openbare orde   |
|                                     | 22 Handhaving openbare veiligheid   |
| 9 Rechtsorde                        | 23 Rechtspleging en detentie  |
|                                     | 24 Rechtshandhaving   |
| 10 Openbaar bestuur                 | 25 Diplomatieke communicatie  |
|                                     | 26 Informatieverstrekking overheid  |
|                                     | 27 Krijgsmacht  |
|                                     | 28 Besluitvorming openbaar bestuur  |
| 11 Transport                        | 29 Mainport Schiphol  |
|                                     | 30 Mainport Rotterdam   |
|                                     | 31 Hoofdwegen- en Hoofdvaarwegennet (Rijksinfrastructuur)                     |
|                                     | 32 Spoor  |
|                                     | 33 Vervoer, opslag en productie/verwerking van chemische en nucleaire stoffen |
| 12 Chemische en nucleaire industrie |   |



Figure 63: Vital sectors, products and services [13]

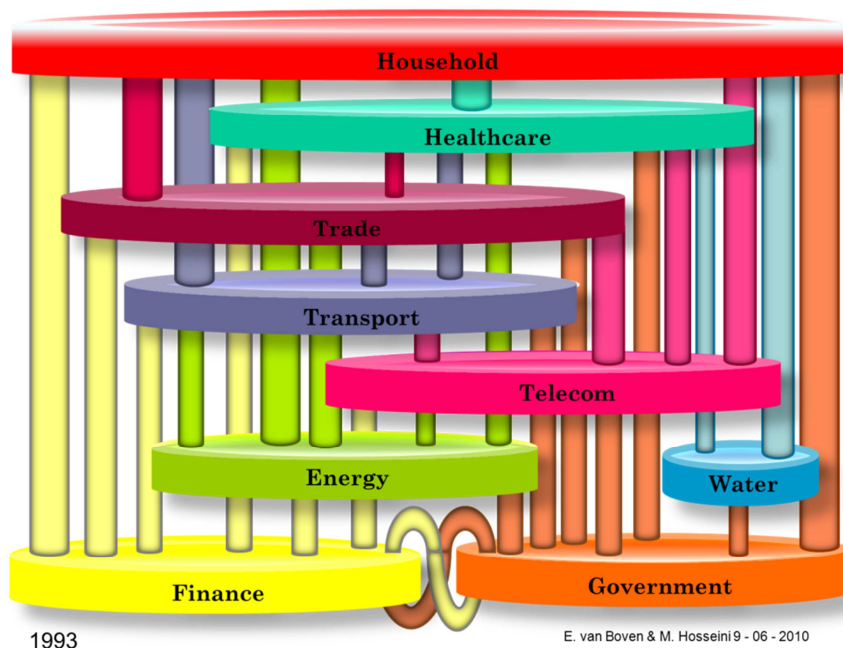


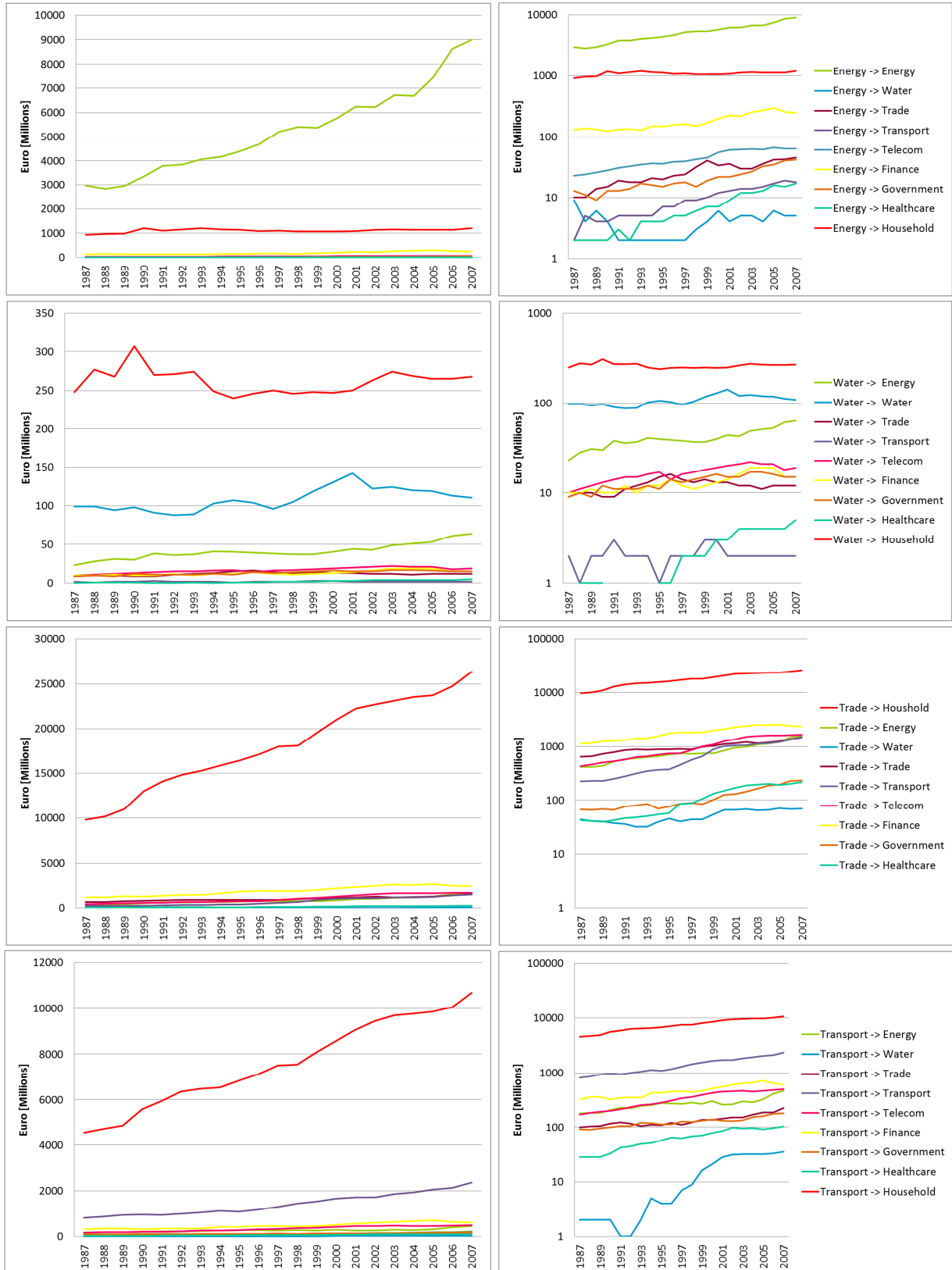
Figure 64: Hierarchic graph of the vital sectors (unidirectional graph)

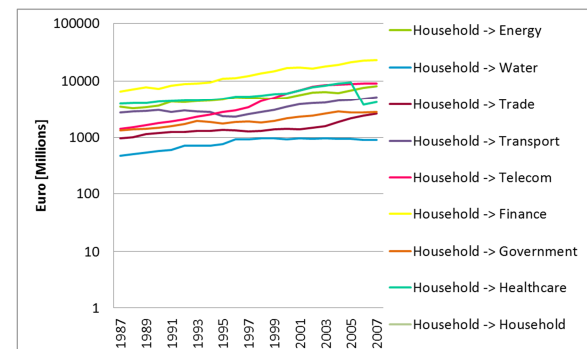
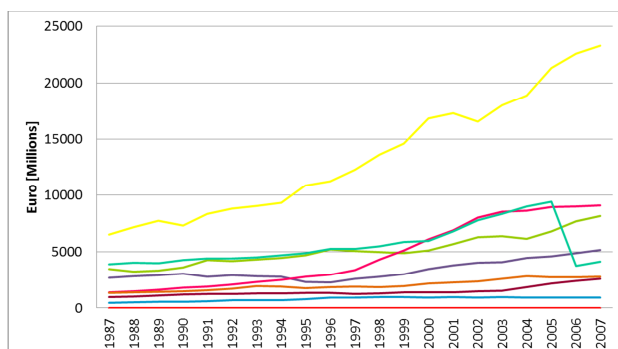
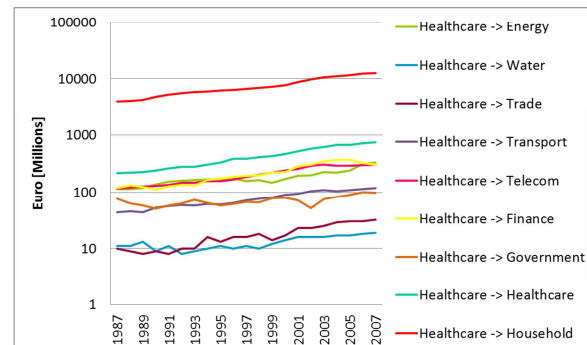
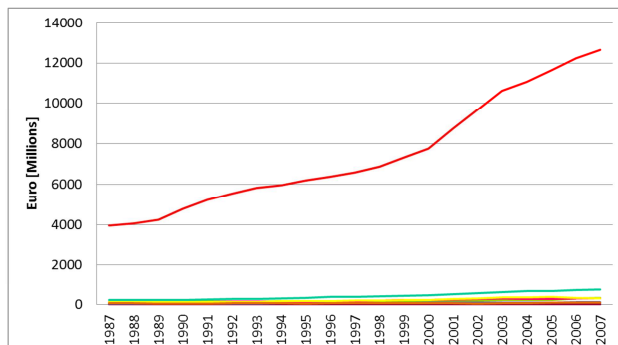
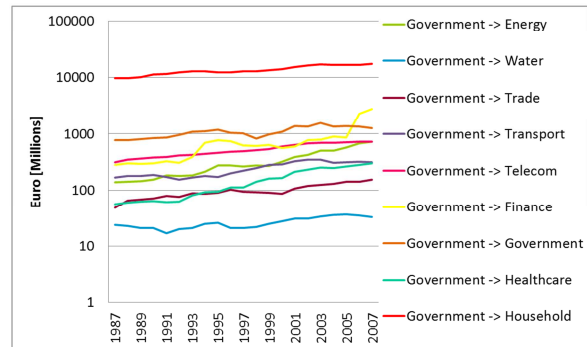
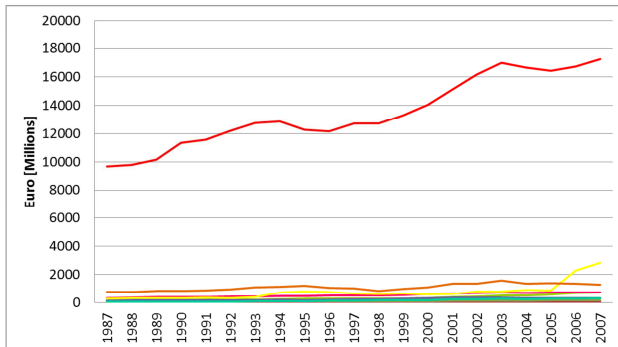
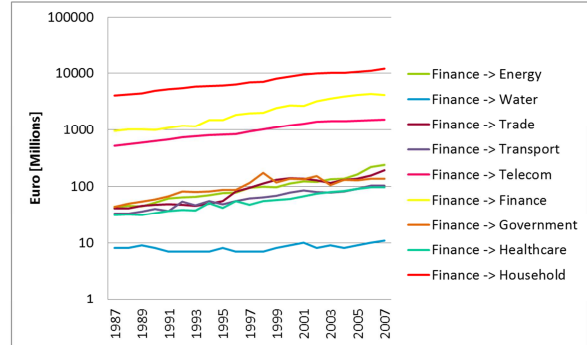
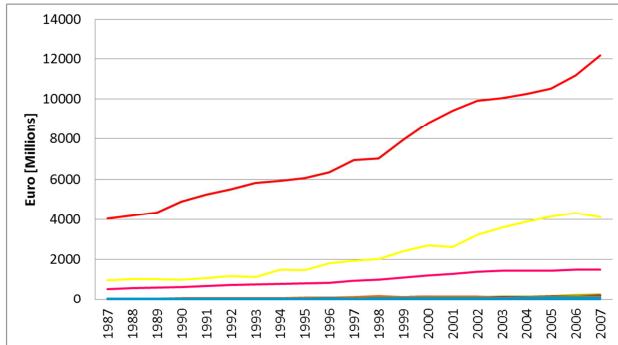
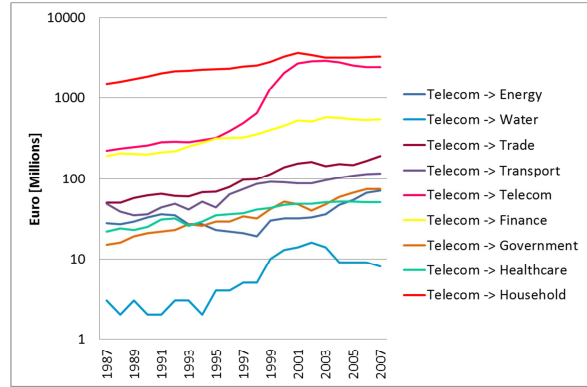
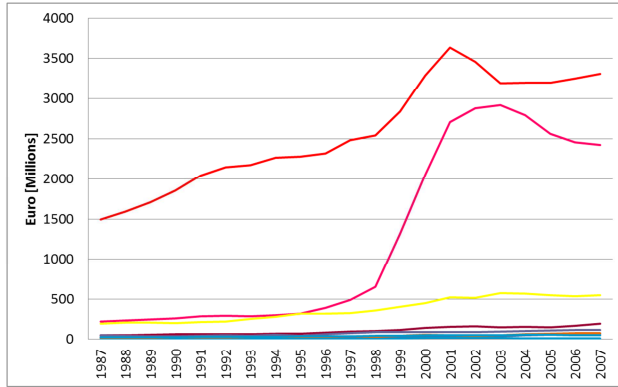
Figure 64 shows the dependencies of the vital sectors in a hierarchic graph. The columns in the image indicate the relationship of each sector to another. In the top, we see the households, where all other sectors provide a service or product.



### C.1 Transactions between vital sectors in millions of euros

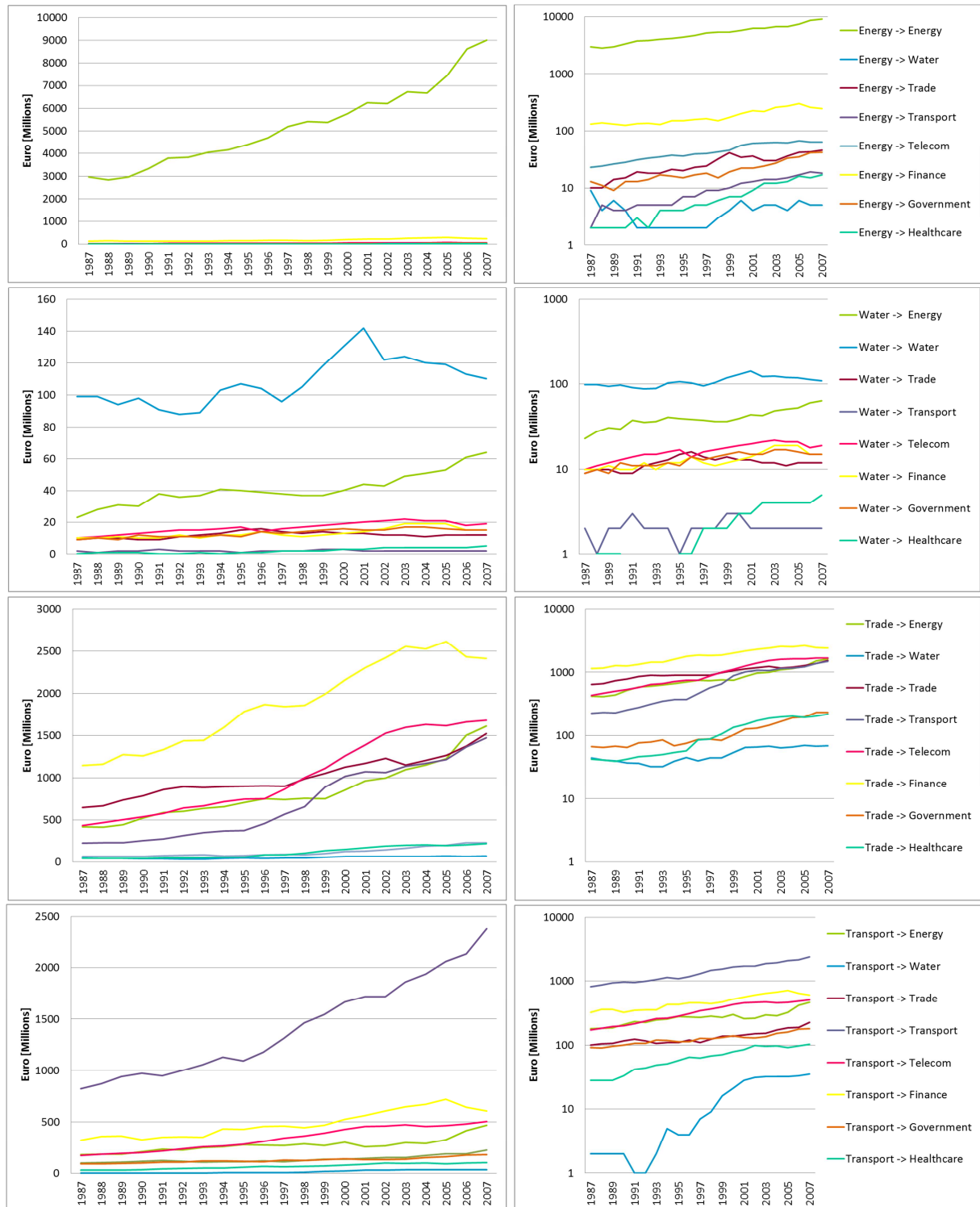
The diagrams below show the monetary transactions between vital sectors. The left columns are the figures based on linear scale and the right columns are based on logarithmic scale. The colour of each line represents the destination sector. In these figures the salaries are also included. The red line in each graph corresponds to the amount of money transacted from the corresponding sector to household sector.

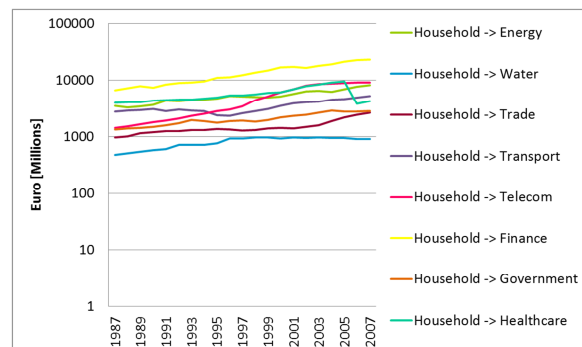
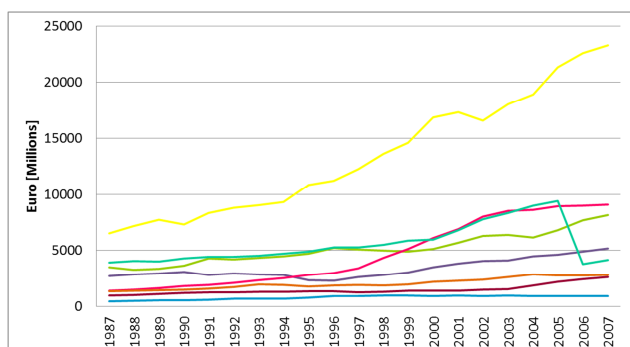
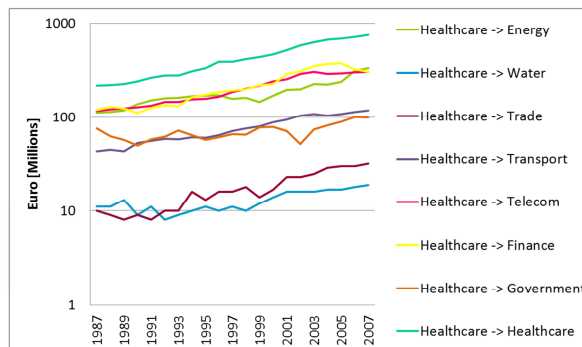
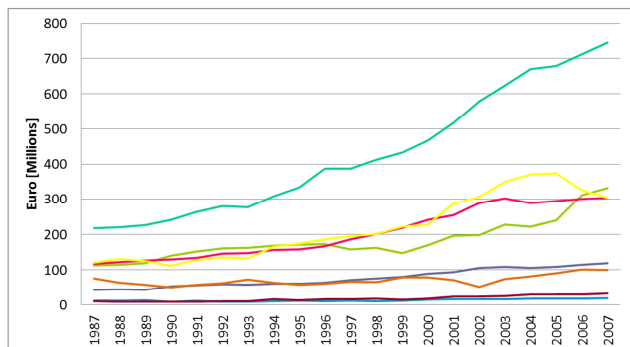
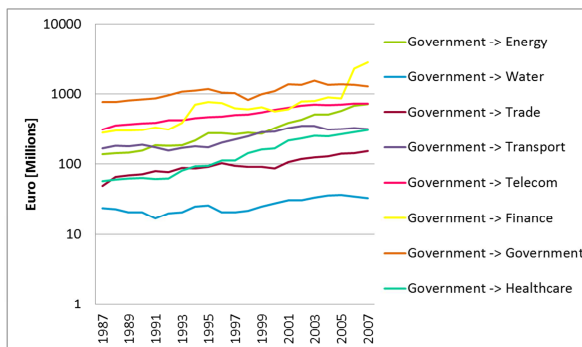
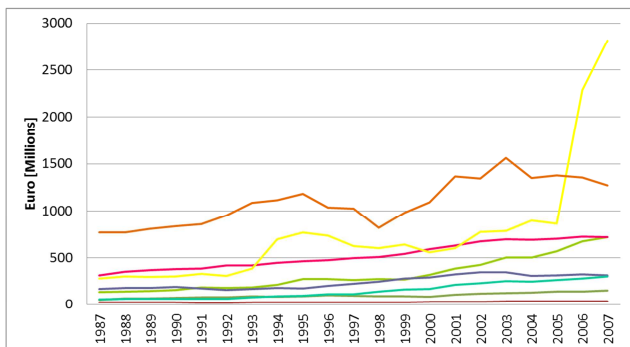
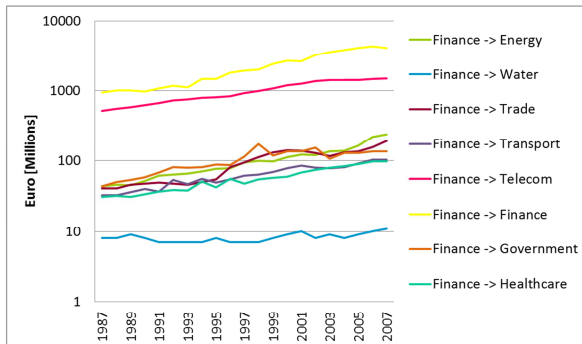
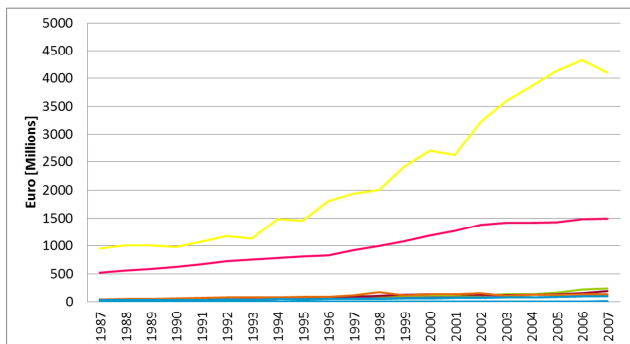
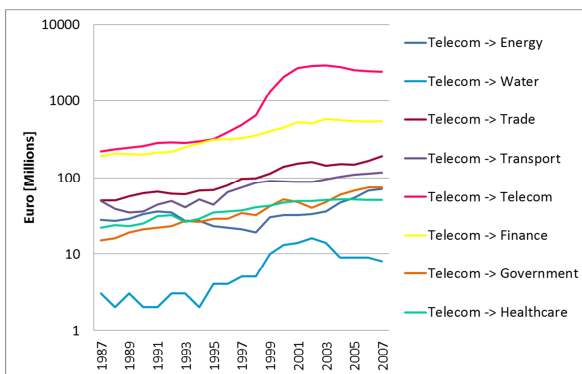
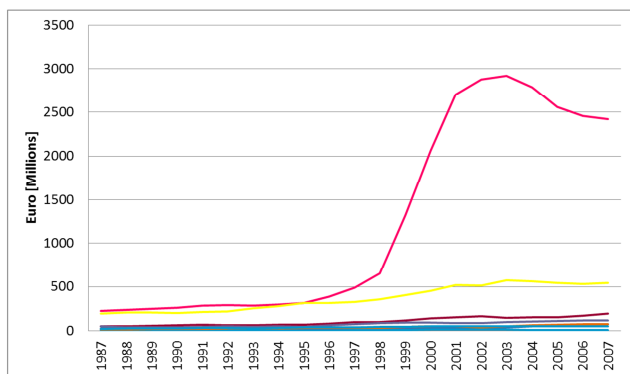




## C.2 Transactions between vital sectors in millions of euros, without salaries

The diagrams below show the monetary transactions between vital sectors. The left columns are the figures based on linear scale and the right columns are based on logarithmic scale. The colour of each line represents the destination sector. In these figures the salaries are not included. The result shows the transactions between sectors more clearly.





### C.3 Trend analysis 2000, 2010 and expert expectations 2020

Table 14 shows the extended trend analysis of 2000, 2010, and innovation expert expectations 2020. This table shows the evolution of the related concepts to the Household, Telecom and Energy sector. The most important part is the last column, which predicts future concepts, mentioned by innovation experts.

**Table 14: Trend analysis 2000, 2010 and expert expectations 2020**

| Concept                              | 2000   | 2010   | Expectations 2020*  |
|--------------------------------------|--|--|---|
| <b>Message From A To B</b>           | letter, fax, email, SMS, chat  | letter, fax, email, chat, SMS, ping  | email, SMS, ping, video attachment, scanning mail, generic chat, location update, ambient-, short voice-, conditional-messaging,                        |
| <b>Energy Generation and Storage</b> | centralised, non- sustainable  | centralised, partly decentralised sustainable < 10%  | centralised, partly decentralised, sustainable >30%, Smart Grid   |
| <b>Content Generation</b>            | journalist, studio's: Hollywood, Hilversum,                                      | studio's: Hollywood, animoto.com, decentralised generation, journalist, blogger , near real time consumer production | Artificial Intelligent content generation, AI image recognition adding context to content, meta data, real time content production, journalist, blogger |
| <b>Content distribution</b>          | TV broadcast, newspaper, stores, CD, LP, satellite channels, "videotheek", Kazaa | TV broadcast, newspaper, NU.nl, video on demand, DVD, Blu-ray, satellite channels, YouTube, Twitter                  | TV broadcast, digital newspaper, video on demand, Blu-ray, satellite channels, YouTube, Leanback, live streaming  |
| <b>Personal Content</b>              | analog camera, photo album ontwikkelen, video tape                               | digital camera, photo album on web, USB, laptop, mobile devices  | personal digital communality, digital cameras, video collection   |
| <b>Security in Payment</b>           | cash money, credit card, pin, cheque   | cash money, credit card, pin, chipknip, cheque, internet banking   | cash money, internet banking, mobile payment, electronic wallet, social currency, sensor interaction, DNA based   |
| <b>Travelling</b>                    | flight ticket, train ticket, hotel   | e-ticket, OV chip card, Hotel, "woningruil", airbnb.com, crashpadder.com   | couch surfing, peer-to-peer hotel, breakfast networks, hotel.com, experience, artificial mobility   |
| <b>Payment For Transport</b>         | fuel costs + road tax + insurance, post TNT                                      | fuel costs + road tax + insurance, company based parcel transfer: post TNT   | pay for actual travel, road pricing, consumer based parcel transfer   |

| Concept  | 2000  | 2010   | Expectations 2020*  |
|--|---|--|---|
| <b>Trade</b>   | shops, urban market, mail order, viavia newspaper | shops, urban market, internet shops, marktplaats.nl, eBay                          | shops, urban market, transaction engines (supply/demand matching), marktplaats.nl, eBay   |
| <b>Representation</b>                                    | secretary, self-organising, business card         | secretary, business card, LinkedIn, outlook msn smileys                            | LinkedIn (audio, video), outlook, avatars, personal assistants , augmented reality  |
| <b>Presence</b>  | physical world                                    | physical world, cyber space, second life, social networks: Facebook, hyves.nl      | presence in several places simultaneously, tele-presence, physical world, cyber space, social networks: Facebook, hyves.nl                                    |
| <b>Advertising</b>                                       | TV-, newspaper-, online-advertisement             | TV-, newspaper-, online-, context related-advertisement, ratings                   | TV-, newspaper-, online-, personal-, context related-, presence/location based-advertisement, ratings, feedback loops, social opinions, interactive gaming/TV |
| <b>Security in Telecom transport and access networks</b> | specific access type per user group               | mix of public and private network  | public and private networks both using single VPN over the same network, mobile AAA for VAS   |
| <b>Quality in Telecom transport network</b>              | various access quality classes                    | still a lot of classes, but only two are relevant: best effort and premium traffic | less access types e.g. fibre can handle lot of traffic in one link  |
| <b>Identity management</b>                               | Passport, driving license, sofi-nummer            | Passport, driving license many different accounts, DigiD, BSN                      | Passport, driving license, ID exchange, DigiD, BSN, linked network of trusted parties, linked ID, electronic signature  |
| <b>Internet of things</b>                                | only the PCs connected to www                     | PC, pda, mobile phone, smart phones, gaming devices, PS3 , iPhone, iPad            | PC, TV, pda, mobile phone, smart phones, iPhone, iPad, M2M, cars  |
| <b>Communications Healthcare</b>                         | doctors visit, telephone                          | doctors visit, telecare, telehealth, doctor assistance, telephone                  | telecare, telehealth, doctor assistance, video conferencing, artificial doctor, distance operation, telephone   |

## D Energy sector

### D.1 Dutch electricity market and infrastructure

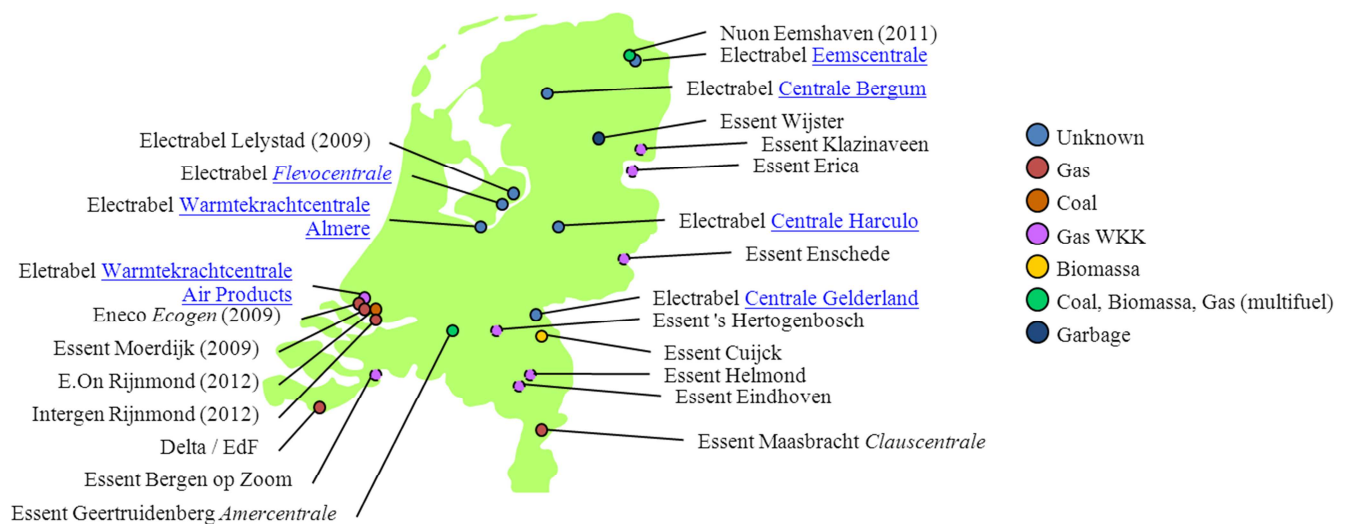
In the electricity market in The Netherlands, there are different types of players. These are electricity producers, suppliers of electricity, retailers of electricity, and the network operators. The network operator (utility operator) is responsible for the physical transport of electricity. It must apply a government-regulated rate, the capacity rate.

Although most consumers only purchase electricity, a small minority of businesses and consumers locally produce electricity and hand it over back into the grid. They are also referred to as “prosumers”.

The Dutch electricity market consists of several parties:

1. Energy Producers
2. Tennet: the operator of the national high voltage power network ( $\geq 110$  kV)
3. Regional Grid Operators: controlling the regional high voltage distribution grid (10 to 110 kV) and low voltage networks.
4. Program Managers: they buy power for the supplier and have a duty to deliver.
5. Suppliers: they supply power to customers, both individuals and businesses.

For example NUON performs the roles (1, 4 and 5) mentioned above. Other parties e.g. Liander only perform one role being a Regional Grid Operator



**Figure 65: Electricity production in Netherland**

Figure 65 shows the centralized electricity plants, the colours of the circles corresponds to the type of the plant. This picture shows the current Dutch situation in which many centralized locations producing electricity in a non-sustainable manner. The government is still planning to add more electricity generation plants.

Since first of July 2004, the Dutch energy market is released by government to promote (price) competition among energy suppliers and create more freedom of choices for the end-users. By splitting of the energy companies, the difference is created between the energy suppliers and the companies that manage the energy and provide transport networks. For the Dutch households, the open energy market means they can choose from which energy provider company they take electricity and gas.

## D.2 Sustainable energy sources

The most important renewable sources are listed below:

**Solar energy** – consist of different variants, which are briefly explained below:

- Solar panels convert sunlight into electricity using Photovoltaic (PV) cells, which is the most popular form.
- Solar collectors convert sunlight into heat. Especially cheap, major versions, such as tubes in asphalt, roofing and exterior walls can be combined with heat storage in groundwater and a heat pump to lead huge CO<sub>2</sub> reductions in the Energy sector.
- Roofs also convert sunlight energy into heat (without having to be visible in or on a building).
- Solar Tower – Using solar energy in a vertical pipe whereby a steady air flow developed. This system may have a capacity equal to a conventional power plant.
- Photo Electro Chemistry (PEC) cells – These are rather like two layers of one conductive solid electrode and a liquid as the other. They can directly use sunlight to decompose water into hydrogen and oxygen.

*Advantages:* little pollution of the environment

*Disadvantages:* depending on the amount of Sun, today's solar cells are still expensive

**Geothermal energy** – is the stored heat in the accessible part of the earth's crust. It includes the energy stored in the soil that may be withdrawn and used. It can either be used directly, such as for heating and cooling in the heat market (heat pump heating), as well as for generating electricity or in a combination of heat and power.

*Advantages:* It provides comfort in your home (e.g. floor heating)

*Disadvantages:* -

**Wind energy** – A wind turbine uses the power of the wind to drive an electric generator and thus generate electricity.

- Large wind turbines (height up to 100 meters, used for wind parks)
- Small wind turbines (that can be easily integrated into an urban environment, e.g. on the roof of tall buildings)

*Advantages:* little pollution of the environment

*Disadvantages:* depending on the amount of wind, affect the living environment of animals because the windmills are so large.

**Hydroelectric power** – refers to production of electrical power through the use of water level difference, usually by building a dam or a natural waterfall.

*Advantages:* no air pollution

*Disadvantages:* fishes die by water consumption, there is a change in the environment of all kinds of animals and plants.

**Bio-energy** – Biological methods are based on photosynthesis, such as the use of bio-waste or the cultivation of bacteria that produce oil. Furthermore, trees, elephant grass or other fast-growing plants which were destroyed or generated fermentable biomass could be used. The efficiency of this process is limited because photosynthesis can exploit only 1% of the energy from the sun.

*Advantages:* No additional CO<sub>2</sub> emissions

*Disadvantages:* However, emissions from other pollutants that lead to environmental degradation (when trees are harvested) may cause changes in the habitats of animals and plants.

**Hydrogen** – Hydrogen is another option, which is seen as the sustainable energy of the future. Combustion of hydrogen, in fact, releases no carbon dioxide (CO<sub>2</sub>). However, there are still many problems to solve. One is the production of hydrogen. That must be produced environmentally friendly otherwise the use of hydrogen from an environmental viewpoint doesn't make sense. Hydrogen is very popular in car industry,



as there are already many hydrogen fuel cell cars and H2ICE (hydrogen fuelled internal combustion engine) vehicles on the roads.

*Advantages:* No CO<sub>2</sub> emission (if electrolyse of water is realized by non-polluting sources); it can be used as battery (see Figure 50) which is a clean, efficient and flexible energy storage.

*Disadvantage:* Hydrogen is very expensive because it needs bulky and heavy tanks, it needs external electricity to be generated.

### **D.3 Classic large scale energy storage**

The three most important technologies for The Netherlands large scale energy storage is outlined below, which are explained briefly:

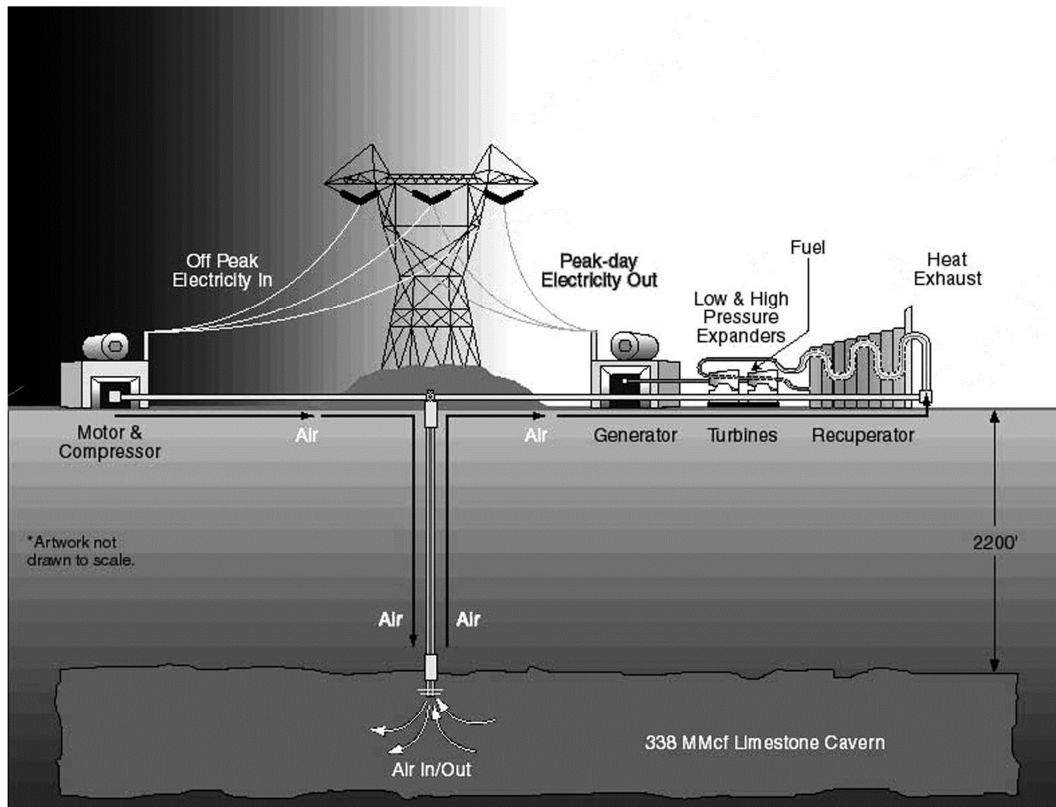
#### **Pumped Storage System**

A Pumped Storage System (PAC) is a hydroelectric power station (at night) pumping water from a lower to an upper reservoir. If the morning peak loads, the floodgates open and water flows through the falling water-powered generators. Electricity generated by turbines driven by Water from the elevated reservoir to flow downward (energy level converted into electrical energy). Energy storage takes place opposite where the turbines are used as a pump. A PAC can be distinguished between natural inflow of water into the upper reservoir and a PAC with pumping the inflow water to the upper reservoir, which might be an option for The Netherlands. In such a system with low-level of height between the reservoirs the conversion efficiency depends on the water level in the reservoirs: the emptier the tank, the more inefficient.

#### **Underground pumped storage system**

An underground pumped storage system (OPAC) differs from the PAC-system in the sense that one of the two reservoirs is installed deep in the ground. In a flat country like The Netherlands, it can be an advantage, since increase in height between the reservoirs and therefore the conversion efficiency will be independent of the water level in the reservoirs.

By pumping up the water at the times of cheap electric power when there is oversupply, and let it flow downhill through the power generator at a later time, the storage system will achieve high efficiency. Moreover, use of existing underground tanks can decrease the investment required for installation. Countries like Germany, France, Britain and Belgium have been using such systems for many years, particularly for stabilization of the national grid.



**Figure 66: Representation of the compressed-air energy storage concept<sup>24</sup>**

**Compressed Air Energy Storage System**

A Compressed Air Energy Storage System (CAES) does not use water, but it uses compressed air as a medium for storing mechanical energy. When a compressor is used to compress air, energy is stored in the air pressure, which might subsequently be used to do work. CAES generally uses the underground, closed caverns which can be brought to high pressure level. After the heating of the air in caverns, the released air pressure is incorporated in a combined steam and gas combustion process with a high efficiency, whereby the electricity is produced.

<sup>24</sup> Source: <http://www.sandia.gov/media/NewsRel/NR2001/norton.htm>

## E Home related connections and standards

### E.1 Fixed connections

*Dial-up connection* (up to 128 Kbps), which uses an analog or ISDN modem and connects to an ISP through a telephone line.

*Asymmetric digital subscriber line, ADSL* (up to 8 Mbps downstream, 1 Mbps upload), hereby connection runs the Internet via a telephone line to the local switch, then the connection continues over to fibre. The ADSL signal on telephone line is separated in frequency, so that telephone and internet connections can both be used simultaneously. The term “asymmetric” refers to the difference in upload and download speed. One problem with using the telephone in this way is that the maximum speed deteriorates with the length of copper wire used. The Internet speed is dependent on the distance to the local exchange.

*ADSL2, ADSL2 +* (up to 24 Mbps download and 1.3 Mbps upload). This is a new form of ADSL, which mainly provides faster download speeds.

*Very high bit rate digital subscriber line, VDSL, VDSL2* (up to 52-200 Mbps downstream, 13 Mbps upload), which are the next-generation DSL connections. VDSL2 is since September 2009 in 40 cities of Netherlands with a maximum speed of 60 Mbps downstream and 6 Mbps upload. The higher speed is achieved by using the copper phone line only in the portion of the connection between home and the street level. From street level, the signal is further transmitted via optical fibre.

*Cable Internet* (up to 200 Mbps download, 108 Mbps upload, according to DOCSIS 3.0) runs the Internet through RTV coaxial cable "next" to radio and television signals to the local switch, and then further over fibre. Subscriptions with download speeds of 50-120 Mbps are already widely available.

*Fibre* (often up to about 100 Mbps for download and sometimes upload). In the fibre networks, the fibre optic cables are rolled to the home or office. The phone or cable RTV is possible only within the home or office use. There are two common methods:

- *Fibre to the Home (FTTH)* the fibre optic cables run into individual homes. This often requires extensive work to install the new cable in the home or office. FTTH is therefore, considered mainly in new house construction projects.
- *Fibre to the Building (FTTB)* is another alternative where the construction of fibre is made only to the outer edge of the building. The Internet is provided via an internal network (LAN) or the traditional telephone line to the end user.

*Hybrid Fibre-Coax, HFC* networks use fibre and coaxial broadband connections to realize high speed data (up to 200 Mbps download, 108 Mbps upload). This kind of technology is widely used in cable networks, to provide TV. These networks mostly consist of a head end which is connected to the community centre through a fibre. From the community centre to the end user it is connected by coax. The fibre optic nodes convert the optical signal into an electronic signal and vice versa without interpreting. HFC networks have higher data carrying capacity than DSL and the speed is not limited by the line-length.

## **E.2 Wireless connections**

*WiFi, IEEE 802.11 a/b/g wireless Ethernet* (up to 540 Mbps), is one of the popular wireless technologies used as wireless internet connection at home or near a hotspot (antennae in crowded places such as stations). The range is limitation of WiFi, the signals are received with a regular antenna up to approximately 30 meters away.

*General Packet Radio Service, GPRS* (up to 58 Kbps download, 29 Kbps upload) is another wireless communication technology in which the internet data is transported here via the GSM network, the mobile telephone network, it is also known as 2.5G.

*High-Speed Downlink Packet Access, HSDPA* (7.2 Mbps max), is a packet switched communications, whereby the internet traffic is sent and received via the network of UMTS. However, using new techniques higher speed can be achieved. HSDPA is also known as 3.5G.

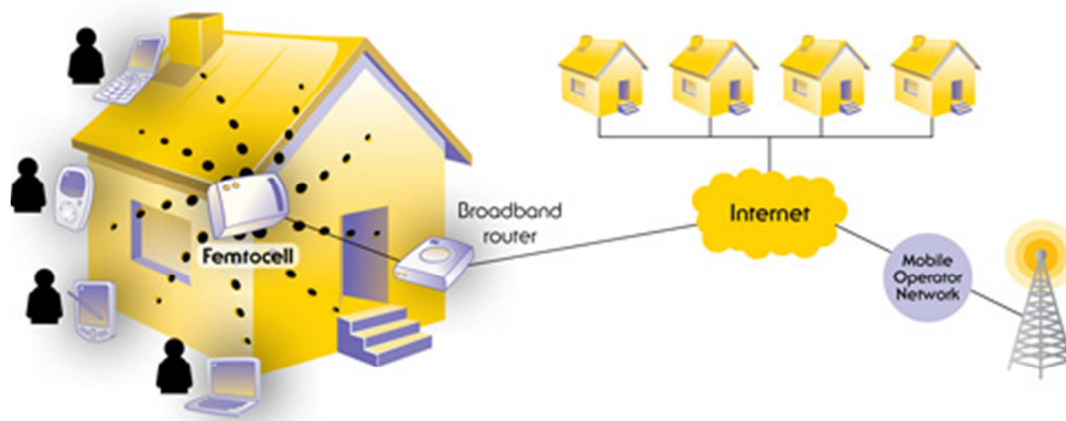
*Worldwide Interoperability for Microwave Access, WiMAX*, comes in two variants. With a slightly misleading name of "Fixed" WiMAX (max.70 Mbps) under this technology a user moves freely in the area of the antenna, with radius up to 50km. The speed in the whole range is dependent of the distance and outside range of antenna the connection dies. Furthermore, remote UMTS masts and Wi-Fi hotspots can be connected to the physical network through WiMAX. This variant is a competitor of broadband via DSL and cable.

"*Mobile WiMAX*" (max. 15 Mbps) is a competitor to UMTS and HSDPA. With this version the user can have unlimited travel without losing the connection. This method makes services such as TV and VoIP over the mobile network perfectly possible.

*Long Term Evolution, LTE* (100 Mbps max) is also known as 4G. This high-speed successor to UMTS / HSDPA is still under development and will be ready to use in the coming years. LTE could largely use existing GSM and UMTS networks.

### *Femto cell*

A Femto cell in mobile telephony is a small cellular base station with a low power typically designed for use in-house or small business. As it is shown in Figure 67, the home network is connected to the mobile network through a broadband internet connection. In the current version, femto cell station supports two to five cell phones simultaneously, for in-house use. The benefit to the user is that the femto cell increases the in-house service quality, where there is no tower nearby.



**Figure 67: The basic idea of a Femto cell [40]**

For the mobile telephone company, there is also a benefit, because the user takes care of the connection between the base station and mobile network, so the in-home usage of the mobile device don't burden the mobile network, which can be beneficial for capacity planning in densely populated areas.

In this way, the mobile network operator can expand their range without many additional expenses.

However, there is a lot focus on femto cells for UMTS. They could also be used for GSM, CDMA2000, TD-SCDMA and WiMAX. A recent study from ABI Research forecasts that by 2011, there will be 102 million users of femto cell products on 32 million access points worldwide [41].

### **E.3 A diversity of in-home standards**

Many different in-home related standards exist serving various purposes. Most of them are incompatible. Some of the in-home related standards are explained bellow.

#### **OSGi**

The Open Services Gateway initiative (OSGi) Alliance specifies a hardware independent dynamic software platform that makes it easier to modularize applications and services via component model and a manage model. The OSGi platform is a Java Virtual Machine (JVM) and is offering to build the OSGi programming framework. The OSGi Alliance consists of large companies such as Sun, IBM, German Telekom, NTT and Oracle, but also from many smaller companies, and others from the open source software field. Therefore, the jointly defined OSGi standard is open to all interested parties and there are appropriately liberal patent laws works. The generic OSGi software platform can be used to control or connect all types of devices, for example, in the automotive field, in mobile phones, in building automation, the intelligent remote control of household appliances or in the "Assisted Living".

An OSGi device is a representation of a physical device or other entity that can be attached by a driver service. OSGi devices that represent physical devices are instantiated by network base drivers. The platform is originally designed for residential gateway and plays an essential role in the home network, especially because often there is no OSGi programming framework installed on the respective devices. The OSGi programming framework is also available for mobile phones and cars. Here they run without the additional gateway, but directly on the powerful embedded hardware. The specification of the OSGi Service Platform defines a Java-based runtime environment above the JVM and its basic services. An important feature of the service platform is the ability to dynamically control service applications at run threat patterns and, most importantly, to also update and remove. With the OSGi Service Platform, it is possible to run several largely independent and modular applications in parallel in the same virtual machine, and this can be done throughout the life cycle of the application remotely. [42][43]

**UPnP**

UPnP enables management at the application layer for home appliances. UPnP standards are based on TCP/IP network and allow devices to connect seamlessly to simplify the implementation of home network for digital content sharing, communication and entertainment. These standards focused on the interconnection between devices and network management [44]. UPnP AV Media Servers are media servers which use the UPnP protocols to communicate with other devices to store and share digital media, such as photos, movies, or music. There are UPnP Media Servers available for most actuation systems and many hardware platforms. UPnP AV Media Servers can be categorized as either software based or hardware based. Software-based UPnP AV Media Servers can be run on PCs, mainly Microsoft Windows, Linux, BSD, Unix or Mac OS X. Hardware-based UPnP AV Media Servers can run on any NAS (Network Attached Storage) devices or any specific hardware for delivering media, such as a PVR (Personal Video Recorder). Currently, there are more software-based UPnP AV Media Servers than there are hardware-based, but it might change in the future.

**DLNA**

The Digital Living Network Alliance (DLNA) is an international association of manufacturers of computers, consumer electronics and mobile phones with the goal to provide interoperability of multimedia equipment from different manufacturers in the home network and ensure personal use. So for example you can use a Sony PS3 to browse your music, videos or photos from your old PC, which is configured as DLNA media server. The DLNA was founded in June 2003 as the Digital Home Working Group (DHWG) by Sony and Intel. The DLNA includes now more than 250 members from 20 countries including Cisco, Ericsson, Hewlett-Packard, Microsoft, Motorola, Nokia, Panasonic, Philips, Samsung, Sharp and Toshiba. The main tasks of the organization include the joint development and continuous updating of technical guidelines (Home Networked Device Interoperability Guidelines) for developers and equipment manufacturers in the field of consumer electronics, computers and mobile devices.

**X10**

X10 is a standard for communication between network devices for home automation. Hereby the power line is used as a medium for the transmission of control signals. The digital data from the X10 protocol is encoded at a 120 kHz carrier signal which coincides with the zero-crossings of the 50 Hz or 60 Hz AC power signal, resulting in a data throughput of 60 bits/sec. The digital data is a network address and a control command, sent from one controller to another controlled device. The X10 technology was originally created in 1974 and an improved version of this protocol was released in 1997. In this version there is extra data can be sent with the status of the devices to verify. This status information may for example consist of a simple status lights on or off. Also, the temperature or other sensor readings are displayed.

**KNX**

KNX is a standard that describes how sensors and actuators communicate with each other. This communication protocol is used in building automation and home automation. KNX Association certifies products according to this standard so that products from different manufacturers together in one system can be used. The KNX is an association of approximately 100 manufacturers, including key players in the electrical, HVAC and white goods market.

The KNX standard is based on the predecessor systems, including EIB, EHS and Batibus. By all bus devices which are connected via the KNX media (twisted pair, radio frequency, power line or IP/Ethernet), information can be exchanged. Bus participants are divided into two categories: sensors and actuators. The KNX communication protocol describes the following applications: lighting, blinds, heating, ventilation, air conditioning, security, audio/video, telecommunications, consumer electronics and display/reporting of sensor and actuator information [45].

## **LONWORKS**

LONWORKS the standard is more flexible than EIB (included in KNX) and is applicable both within the home environment, and within a business environment. This standard is used within operating environments in both large and small companies. It is used for networking of devices over media such as twisted pair, powerline, fibre optics, and RF. LONWORKS in terms of applicability wider than EIB and used for controlling lighting, heating, air conditioning, elevator controls, fire alarm, security and access applications. OSGi Middleware-Standard (Java-Framework) is used for integration of LONWORKS within the residential gateway. LONWORKS is used worldwide and even in Europe - notably Germany - a large user base: the LON Nutzer Organization. LonMark International (which is the association for LONWORKS standard) and its affiliate organizations have grown to nearly 400 members today [46]. An important element in the detriment of the LONWORKS standard is that currently insufficient training opportunities are available for installers. Moreover, there are high costs associated with necessary installation tools.

## **HomePlug**

HomePlug is an open standard for powerline communications developed by the HomePlug Power line Alliance. Member of this alliance includes 3Com, Cisco, AMD, Compaq, Conexant, Intel, Motorola, Panasonic and Texas Instruments. HomePlug is not specifically designed as a solution for home automation, but it competes with wireless standards like WiFi. HomePlug 1.0 standard was developed in 2001. This standard is suitable for data rates up to 14 Mbps. A new version of the HomePlug AV standard to allow speeds of 100 to 200 Mbps, and it is suitable for Voice over IP (VOIP) and High Definition TV (HDTV). Besides the HomePlug alliance, there are other parties recently joined in this market, such as the Consumer Electronics Powerline Communications Alliance (CEPCA) (Sony, Mitsubishi and Panasonic). This alliance has developed a specification for powerline technology that allows speeds up to 170 Mbps. Unfortunately, this standard is not compatible with the HomePlug standard.

## **ZigBee**

ZigBee (IEEE 802.15.4) is an open standard for wireless connections between devices at short distances. It is a complement to Bluetooth and Wi-Fi, it is used for transmitting sensor data and (process) control (monitoring & control) as the health of a patient or safety in the home monitoring using sensors. The goal of the ZigBee was the realization of a low cost, low power, ubiquitous, wireless network technology. An important task of the alliance was the definition of an open industry specification for unlicensed use. ZigBee networks consist of up to 256 nodes and are used in: automation of lighting, heating and security systems, replacement of infrared communication and replacing wired controller technology. The ZigBee architecture supports three types of topologies: the star topology, the cluster-tree topology and mesh topology. The star topology is the simplest form, where one of the nodes functions as the central node. To form a large network, often several star networks are linked together, resulting in a cluster-tree network. Both topologies have the drawback of one or more single point of failures to accommodate, the central node(s). In environments where high reliability is required, the best solution is to furnish a mesh network [47].

The recent Zigbee Health care specification adds medical equipment to the growing list of applications for ZigBee Wireless Sensor Networks. The ZigBee design allows connection with portable, mobile and fixed products, making physical Ethernet cables unnecessary. The devices have a very low current usage. The long battery life can go up to several years depending on the device itself. The design in the form of a mesh network ensures reliable coverage over a large area. The new platform will provide economies of scale in the production of Home Use Medical Devices. Moreover, the manufacturers of equipment rid of the necessity of technical ZigBee specifications to learn them, so they instead concentrate on their own specialization to use their medical expertise more proficiently [48].

## F Definitions

### Smart Home

“A “Smart Home” can be defined as a residence equipped with computing and information technology which anticipates and responds to the needs of the occupants, working to promote their comfort, convenience, security and entertainment through the management of technology within the home and the connections to the world beyond.” (Aldrich, 2003) [35]

### Smart Living

The definition that Professor Nico Baken has mentioned is as follows:

*“The Smart Living program aims to contribute to the improvement of people’s Quality of Life and the sustainable use of limited resources. We can roughly distinguish three areas in which we as humans can move. Either we are at home (in the neighbourhood), elsewhere (e.g. at work, at school) or travelling.*

*The Smart Living program is important because it concerns our homes and neighbourhoods which are important entities to draw...and then we have the four P’s: People, Planet, Profit and Pneuma. It is difficult to organize things on these P’s and to abstract, but you can have an extensive analysis on these domains.*

*The old paradigm where we did many things in a centralized way and everything was completely functionally decomposed, versus another way of working, to which I feel out of brown now, and which is fitting the internet, the prosumer. Well we have to ask ourselves how does the 24 hour living look like, and how does this migrate to the new paradigm, and then we can make value cases that it is appropriate instant with it right now. What I see now, if we want to move to this new paradigm we need to go for value sensitive design, with functional and non-functional requirements incorporated simultaneously.*

*To concretise our understanding of Smart Living, we outline an image of a Smart Living neighbourhood, with concepts like together, decentralized, sustainable and trans-sector”*

### Service bundle

Service bundle can be defined as various levels of functional-content based on customer/individual user’s needs.

### Complex Networks

Complex networks are a relatively new field of research resulted from graph theory that focuses less on the study of small graphs, the properties of individual nodes and links in these graphs, but rather on the statistical properties of large scale networks [7].

### Sector

On a macroscopic level, economy and society have decomposed into a number of sectors that together provide the foundations for our daily lives. A sector can be defined as a cluster of homogeneous activities [4]. From a mathematical perspective a sector can be defined as the area enclosed by two radii of a circle and their intercepted arc (a pie-shaped part of a circle).

### Sector Network

A sector network is a network in which the nodes are sectors.

### Trans-sector Innovation

Trans-sector Innovation is innovation that involves two or more sectors.

### Vital Sector

We speak of vital sectors, containing vital infrastructures, when it comes to products, services and underlying processes which, if they fail, social disruption may cause. This may be because there are many



victims and economic losses, or restoring lasts long and there are no real alternatives, while we cannot miss these products and services [5].

### **Holon<sup>25</sup>**

A holon is an identifiable part of a system that has a unique identity, yet is made up of sub-ordinate parts and, in turn, is part of a larger whole (Arthur Koestler, *The Ghost in the Machine*, Page 47,48) [49]. A “part” means something fragmentary and incomplete, which by itself would have no legitimate existence. On the other hand, a “whole” is considered as something complete in itself which needs no further explanation. But wholes and parts in this absolute sense just do not exist anywhere, either in the domain of living organisms or of social organisations. What we find are intermediary structures on a series of levels in an ascending order of complexity [49]. A definition Prof.dr.ir Nico Baken suggested during a workshop of Statistics Netherlands - TRANS workshop (12 May 2010):

*“A holon can be either conceptual or real. One can distinguish a holon from its environment as a logical entity that is both a whole and a part. A holon can be perceived as a logical entity. A real holon can change as a function of time.”*

### **Telecom**

Given the fact that there is no global consensus about the definition of a sector and the activities that belong to each one of them, below the Telecom sector is defined from classification and a functional perspective. Thus, for the purpose of this thesis, we consider the Telecom sector to be an alternative aggregation, containing all the activities corresponding to division 61, and additionally including the broadcast function mentioned in division 60 in ISIC Rev.4 [6]:

#### **60 - Programming and broadcasting activities**

601 - Radio broadcasting

602 - Television programming and broadcasting activities

#### **61 – Telecommunications**

611 - Wired telecommunications activities

612 - Wireless telecommunications activities

613 - Satellite telecommunications activities

619 - Other telecommunications activities

From a functional perspective, the Telecom sector could be defined as the sector serving both economy and society that offers its Value Added Services (VAS) relying on its unique capability of transferring data by means of electro-magnetic (EM) waves [3].

### **Energy**

Section: D - Electricity, gas, steam and air conditioning supply<sup>26</sup>

Division: 35 - Electricity, gas, steam and air conditioning supply

351 - Electric power generation, transmission and distribution

352 - Manufacture of gas; distribution of gaseous fuels through mains

353 - Steam and air conditioning supply

<sup>25</sup> See also TEDx presentation of Prof.dr.ir. Nico Baken: <http://www.youtube.com/watch?v=EDZtJaefpZE>

<sup>26</sup> Source: <http://unstats.un.org/unsd/cr/registry/regcs.asp?Cl=27&Lg=1&Co=35>

### **Node weight**

A definition for node weight found in the literature is as follows:

*“One expresses a kind of activities, organizations or events, named “acts”; and another expresses the “actors” participating in some acts. In each act the actors basically show collaboration relationship with each other, however they play different roles in the cooperation. Usually every actor tries to play the most important role; therefore the role difference can be regarded as a kind of competition. The node weight usually signifies the role or “importance degree” of each actor.” [50]*

The node weight distribution provides information about the actor competition. In this thesis we are going to investigate the meaning of the node weight within the trans-sector network.

*“The weight  $w_i$  of a node  $i$  can be placed on the diagonal of matrix  $W$ . Matrix  $W$  can be defined as a weighted adjacency matrix. In this way, the node weight can be understood as the weight of a self-loop.”[1]*

### **Cloud**

An emerging computing paradigm where data and services reside in massively scalable data centres and can be ubiquitously accessed from any connected devices over the internet.

### **SCADA**

Supervisory Control And Data Acquisition (SCADA) is defines as the collection, transmission, processing and visualization of measurement and control signals from multiple machines in large industrial systems. Sometimes even unfairly called distributed control systems (DCS). A SCADA system consists of a computer that has SCADA software. A SCADA system facilitates the exchange of measurement data, the visualization of data for the human operator, the influence of these systems (control), and processing the measurement data to reports (data) or warning.

### **Jini<sup>27</sup>**

Jini technology is a technology for building service oriented architectures that defines a programming model which both exploits and extends Java™ technology to enable the construction of secure, distributed systems consisting of federations of well-behaved network services and clients. Jini technology can be used to build adaptive network systems that are scalable, evolvable and flexible as typically required in dynamic computing environments.

---

<sup>27</sup> Source: [http://www.jini.org/wiki/Category:Introduction\\_to\\_Jini](http://www.jini.org/wiki/Category:Introduction_to_Jini)

## G Acronyms

|         |  |
|---------|--|
| ADSL    | Asymmetric Digital Subscriber Line   |
| CAES    | Compressed Air Energy Storage  |
| CCTV    | Closed Circuit Television  |
| CHP     | Combined Heat and Power  |
| DG      | Distributed Generation   |
| DHWG    | Digital Home Working Group   |
| DLNA    | Digital Living Network Alliance  |
| DSM     | Distributed Systems Management   |
| DVB     | Digital Video Broadcasting   |
| EAC     | Electronic Access Control  |
| ECD     | Energy Citations Database  |
| ECN     | stichting Energieonderzoek Centrum Nederland                                     |
| EISA    | Energy Independence and Security Act   |
| ERANET  | European Research Area NETwork   |
| FMCA    | Fixed-Mobile Convergence Alliance  |
| FTTB    | Fibre To The Building  |
| FTTH    | Fibre To The Home  |
| GPRS    | General Packet Radio Service   |
| GSM     | Global System for Mobile communications  |
| HAVi    | Home Audio Video interoperability  |
| HFC     | Hybrid Fibre-Coax network  |
| HLR     | Home Location Register   |
| HSDPA   | High-Speed Downlink Packet Access  |
| HSS     | Home Subscriber System   |
| HVAC    | Heating Ventilation Air Conditioning   |
| HVDC    | High Voltage Direct Current  |
| IaaS    | Infrastructure as a Service  |
| ICCS    | Institute of Communications and Computer Systems                                 |
| IIP-DSL | ICT Innovatie Platform Domotica & Smart Living                                   |
| IMS     | IP Multimedia Subsystem  |
| I/O     | Input Output table   |
| ISET    | Institut für Solare EnergieversorgungsTechnik                                    |
| ISIC    | International Standard Industrial Classification of All Economic Activities      |
| LTE     | Long Term Evolution  |
| MinBZK  | Ministerie van Binnenlandse Zaken  |
| NACE    | Nomenclature générale des Activités Économiques dans les Communautés Européennes |
| NAS     | Network Architectures & Services   |
| NG      | Next Generation  |
| NIST    | The National Institute of Standards and Technology                               |
| OSGi    | Open Service Gateway initiative  |
| PaaS    | Platform as a Service  |
| PAC     | Pumped hydro ACcumulation storage system   |
| PBX     | Private Branch Exchange  |

|       |   |
|-------|---|
| PPC   | Public Power Corporation                        |
| PDF   | Probability Density Function                    |
| QoS   | Quality of Service                              |
| SaaS  | Software as a Service                           |
| SBI   | Standaard Bedrijfsindeling                      |
| SCADA | Supervisory Control And Data Acquisition        |
| SIG   | Special Interest Group                          |
| SN    | Statistics Netherlands                          |
| UAS   | Unattended Autonomous Surveillance              |
| UMTS  | Universal Mobile Telecommunications System      |
| UPnP  | Universal Plug and Play                         |
| V2G   | Vehicle-to-Grid                                 |
| VDSL  | Very high bit rate Digital Subscriber Line      |
| VESA  | Video Electronics Standards Association         |
| VPP   | Virtual Power Plants                            |
| WIMAX | Worldwide Interoperability for Microwave Access |
| WP    | Working People                                  |



```

        end
    end
    for i=1:length(v1)
        s= strmatch( v1(i), v2);
        q=[repmat(v1(i),[length(s),1])
        v2(s)];
        t=[t ; q];
        if isempty(v2)||isempty(q)
            s= strmatch( v1(i), v3);
            n=[repmat(v1(i),[length(s),1])
            v3(s)];
            t=[t ; n];
        end
    end
    for i=1:length(v2)
        s= strmatch( v2(i), v3);
        q=[repmat(v2(i),[length(s),1])
        v3(s)];
        t=[t ; q];
        if isempty(v3)||isempty(q)
            s= strmatch( v2(i), v4);
            n=[repmat(v2(i),[length(s),1])
            v4(s)];
            t=[t ; n];
        end
    end
    for i=1:length(v3)
        s= strmatch( v3(i), v4);
        q=[repmat(v3(i),[length(s),1])
        v4(s)];
        t=[t ; q];
    end
    total=[total ; t];
    else
        w1 = g(h(i): length(g));
        w2 = u(h(i): length(g));
        test
        total=[total ; t];
    end
end

```

---

## Shape.m

```

% this code calculates the shape
size of circles in animation of WP,
and provides the related code for
Cytoscape
g=nx;
b = 120; % maximum size
plot_data
fid = fopen('shape_size_output.txt','wt')
;
for i= 1:length(q1)
    c = round((b/max(q1))*q1(i));
    if c<1
        e = sprintf('%s %s %d',char(u1(i)),
        char(' = '), 1 );
    else
        e = sprintf('%s %s %d',char(u1(i)),
        char(' = '), c );
    end
end

```

```

fprintf(fid, '%s \n',e);
end
for i= 1:length(q2)
    c = round((b/max(q1))*q2(i));
    if c<1
        e = sprintf('%s %s
%d',char(u2(i)), char(' = '), 1);
    else
        e = sprintf('%s %s
%d',char(u2(i)), char(' = '), c);
    end
    fprintf(fid, '%s \n',e);
end
for i= 1:length(q3)
    c = round((b/max(q1))*q3(i));
    if c<1
        e = sprintf('%s %s
%d',char(u3(i)), char(' = '), 1 );
    else
        e = sprintf('%s %s
%d',char(u3(i)), char(' = '), c );
    end
    fprintf(fid, '%s \n',e);
end
for i= 1:length(q4)
    c = round((b/max(q1))*q4(i));
    if c<1
        e = sprintf('%s %s
%d',char(u4(i)), char(' = '), 1 );
    else
        e = sprintf('%s %s
%d',char(u4(i)), char(' = '), c );
    end
    fprintf(fid, '%s \n',e);
end
for i= 1:length(q5)
    c = round((b/max(q1))*q5(i));
    if c<1
        e = sprintf('%s %s
%d',char(u5(i)), char(' = '), 1 );
    else
        e = sprintf('%s %s
%d',char(u5(i)), char(' = '), c );
    end
    fprintf(fid, '%s \n',e);
end
fclose(fid);

```

---

## Colour.m

```

% this code produces colour codes
for Cytoscape of each node in
animation of WP the shape
fid = fopen('exp.txt','wt');
for i = 1: length(g)
    switch length(char(g(i)))
        case 1
            e = sprintf('%s',char(''),
            char(g(i)), char(''), '=
51,255,0');
            fprintf(fid, '%s \n',e);
        case 2

```

```

    e = sprintf('%s',char(''),
char(g(i)),      char(''),      '=
255,0,0');
    fprintf(fid,'%s \n',e);
    case 3
    e = sprintf('%s',char(''),
char(g(i)),      char(''),      '=
0,0,156');
    fprintf(fid,'%s \n',e);
    case 4
    e = sprintf('%s',char(''),
char(g(i)),      char(''),      '=
149,179,215');
    fprintf(fid,'%s \n',e);
    case 5
    e = sprintf('%s',char(''),
char(g(i)),      char(''),      '=
0,204,255');
    fprintf(fid,'%s \n',e);
    end
end
fclose(fid);

```

---

## Plot\_data.m

% this function divides the data of a year in each of the 5 hierarchy layers (WP), this function is used by Sort\_data.m

```

g = nx;
N = length(g);
u1=[];
u2=[];
u3=[];
u4=[];
u5=[];
q1=[];
q2=[];
q3=[];
q4=[];
q5=[];
for i = 1:N
    if length(char(g(i)))==1
u1=[u1 ; g(i)];
q1=[q1 ; p(i)];
    end
    if length(char(g(i)))==2
u2=[u2 ; g(i)];
q2=[q2 ; p(i)];
    end
    if length(char(g(i)))==3
u3=[u3 ; g(i)];
q3=[q3 ; p(i)];
    end
    if length(char(g(i)))==4
u4=[u4 ; g(i)];
q4=[q4 ; p(i)];
    end
    if length(char(g(i)))==5
u5=[u5 ; g(i)];
q5=[q5 ; p(i)];
    end
end

```

end

---

## Sort\_data.m

```

% this function generates excel
files with Sections, Divisions,
Groups, Classes, Subclasses of
number of working people (WP)
year = [1993, 1994, 1995, 1996,
1997, 1998, 1999, 2000, 2001, 2002,
2003, 2004, 2005];
s=[ d93, d94, d95, d96, d97, d98,
d99, d00, d01, d02, d03, d04, d05];
z={'A1','B1','C1','D1','E1','F1','G
1','H1','I1','J1','K1','L1','M1'};
x={'A','B','C','D','E','F','G','H',
'I','J','K','L','M'};
x=x(:)
sections = []
divisions = [];
groups = [];
classes = [];
subclasses = [];
for i=1:13
    p=s(:,i)
    plot_data;
    sections = [sections q1];
    divisions = [divisions q2];
    groups = [groups q3];
    classes = [classes q4];
    subclasses = [subclasses q5];
    s=[ d93, d94, d95, d96, d97,
d98, d99, d00, d01, d02, d03, d04,
d05];
end
xlswrite('Sections.xls',sections,'s
heet1', 'A1');
xlswrite('Divisions.xls',divisions,
'sheet1','A1');
xlswrite('Groups.xls',groups,'A1');
xlswrite('Classes.xls',classes,'A1'
);
xlswrite('Sub_classes.xls',subclass
es,'A1');

```

---

## Network.m

%% this function provides the monetary network from I/O table, also generates input file for Cytoscape

```

p = []; %network
r = [];
h = [];
d = []; %degree
e = 0; %variable
x=y1993;
x(isnan(x))=0;
q=x(105,:);
m=x(:,105);

```

```

x(105,:)=m';
x(:,105)=q';
s= [50, 51, 61, 62, 64, 65, 66, 67,
68, 69, 70, 71, 72, 74, 75, 76, 89,
90, 91, 92, 96, 105];
%% this code provides the network
of each year for the specific range
for i= 1:105
    for j = 1:105
        e = x(i,j);
        if e > 1
            h = [i j];
            r = [r;h];
        end
    end
end
for i=1:length(r)
    if (sum(bsxfun(@eq,s,r(i,1)))>0
|| sum(bsxfun(@eq,s,r(i,2)))>0)
        p = [p ; r(i,:)];
    end
end

%% this for-loop calculates the
degree vector
for i = 1:105
d(i)= sum(sum(bsxfun(@eq,i,p)));
end

%% this code gives colour to the
links in the network
fid = fopen('linkcolour.txt','wt');
for i=1:length(p)
switch p(i,1)
    case 50
        e = sprintf('%d\t%s\t%d%s',
p(i,1), '(pp)', p(i,2), ' =
153,204,0');
        fprintf(fid,'%s \n',e);
    case 51
        e = sprintf('%d\t%s\t%d%s',
p(i,1), '(pp)', p(i,2), ' =
0,153,204');
        fprintf(fid,'%s \n',e);
    case 61
        e = sprintf('%d\t%s\t%d%s',
p(i,1), '(pp)', p(i,2), ' =
153,0,51');
        fprintf(fid,'%s \n',e);
    case 62
        e = sprintf('%d\t%s\t%d%s',
p(i,1), '(pp)', p(i,2), ' =
153,0,51');
        fprintf(fid,'%s \n',e);
    case {64, 65, 66, 67, 68,
69, 70, 71, 72}
        e = sprintf('%d\t%s\t%d%s',
p(i,1), '(pp)', p(i,2), ' =
102,102,153');
        fprintf(fid,'%s \n',e);
    case 74

```

```

        e = sprintf('%d\t%s\t%d%s',
p(i,1), '(pp)', p(i,2), ' =
255,0,102');
        fprintf(fid,'%s \n',e);
    case {75, 76}
        e = sprintf('%d\t%s\t%d%s',
p(i,1), '(pp)', p(i,2), ' =
255,255,0');
        fprintf(fid,'%s \n',e);
    case {89, 90, 91, 92}
        e = sprintf('%d\t%s\t%d%s',
p(i,1), '(pp)', p(i,2), ' =
226,107,10');
        fprintf(fid,'%s \n',e);
    case 96
        e = sprintf('%d\t%s\t%d%s',
p(i,1), '(pp)', p(i,2), ' =
0,204,153');
        fprintf(fid,'%s \n',e);
    case 105
        e = sprintf('%d\t%s\t%d%s',
p(i,1), '(pp)', p(i,2), ' =
255,0,0');
        fprintf(fid,'%s \n',e);
end
end
fclose(fid);

```

---

## Degree.m

```

%% this code provides a degree
matrix of all the years
deg = [];
x = [];
IO=[y1987, y1988, y1989, y1990,
y1991, y1992, y1993, y1994, y1995,
y1996, y1997, y1998, y1999, y2000,
y2001, y2002, y2003, y2004, y2005,
y2006, y2007];
IO(isnan(IO))=0;
for n = 1:21
p = []; %network
r = [];
d = [];
e = 0;
x = IO(:,n*105-104:n*105);
q = x(105,:);
m = x(:,105);
x(105,:)=m';
x(:,105)=q';
%% this code provides the network
of each year for the specific range
for i= 1:105
    for j = 1:105
        e = x(i,j);
        if e >= 5000
            h = [i j];
            r = [r;h];
        end
    end
end
for i=1:length(r)

```



```

        if (sum(bsxfun(@eq,s,r(i,1)))>0
|| sum(bsxfun(@eq,s,r(i,2)))>0)
            p = [p ; r(i,:)];
        end
    end
end
%% this for-loop calculates the
degree vector
for i = 1:105
d(i)= sum(sum(bsxfun(@eq,i,p)));
end
deg = [deg d'];
end
xlswrite('IO_grgl_5000_degree(1987-
2007).xls',deg,'sheet1', 'A1');

```

---

## Dependencies.m

```

%% this code provides the
dependency values for the
hierarchical vital sector
dependencies graph
k=log(data);
u = max(max(k));
m = [];
for i= 1:length(k)
    for j=1:3
        if k(i,j) <= (u/5)
            m(i,j)=1
        end
        if ((u/5)< k(i,j)) &&
(k(i,j)<= (u/5*2))
            m(i,j)=2
        end
        if ((u/5*2)< k(i,j)) &&
(k(i,j) <= (u/5*3))
            m(i,j)=3
        end
        if ((u/5*3) < k(i,j)) &&
(k(i,j) <= (u/5*4))
            m(i,j)=4
        end
        if ((u/5*4) < k(i,j))
(k(i,j)<= u)
            m(i,j)=5
        end
    end
end
end

```

---

## Mainsort.m

```

% this function uses Sorting.m and
generates Xcel file IO_listed_1987-
2007
IO=[y1987, y1988, y1989, y1990,
y1991, y1992, y1993, y1994, y1995,
y1996, y1997, y1998, y1999, y2000,
y2001, y2002, y2003, y2004, y2005,
y2006, y2007];
IO(isnan(IO))=0;
z=[];
g=[];
for i =1:21

```

```

z= sorting(IO(:,i*105-104:i*105))
g=[g z];
end
xlswrite('20100929 IO_listed_1987-
2007.xls',g,'sheet1', 'A1');

```

---

## Sorting.m

```

% this function selects the vital
activity clusters in the I/O data
set and sort it in one matrix
function[value]=sorting(x)
x(isnan(x))=0;
t=[];
b=[];
y=[];
value=[];
s= [50, 51, 61, 62, 64, 65, 66, 67,
68, 69, 70, 71, 72, 74, 75, 76, 89,
90, 91, 92, 96, 105];
for i=1:length(s)
    t= [t ; x(s(i),:)]];
end
b=[t(1,:); t(2,:); sum(t(3:4,:));
sum(t(5:13,:)); t(14,:);
sum(t(15:16,:)); sum(t(17:20,:));
t(21,:); t(22,:)];
b=[b; sum(x)-sum(b)];
% here we calculate the "others
sector" sum of total minus sum of b
y=[b(:,50) b(:,51)
sum(b(:,61:62))' sum(b(:,64:72))'
b(:,74) sum(b(:,75:76))'
sum(b(:,89:92))' b(:,96)
b(:,105)];
y=[y sum(b)']-sum(y)'];
value= reshape(y,100,1)

```

---

## Mapping.m

```

% this code maps the WP with I/O
data set
v = names;
w = values;
w(isnan(w))=0;
m=[];
sn=[];
c=[];
d=[];
g=[];
r=[];
h=[];
n=[];
f=[]; % this is the set
of diagonal elements of 1993-2005
e=[];
IOSN=[];
map=[]; % this matrix will
contain working people corespondin
to IO table rows
s=[d93,d94,d95,d96,d97,d98,d99,

```

```

d00,d01,d02,d03,d04,d05];
jr=[1993, 1994, 1995, 1996, 1997,
1998, 1999, 2000, 2001, 2002, 2003,
2004, 2005];
IOS=[y1993, y1994, y1995, y1996,
y1997, y1998, y1999, y2000, y2001,
y2002, y2003, y2004, y2005];
IOS(isnan(IOS))=0;
y = [50, 51, 61, 62, 64, 65, 66,
67, 68, 69, 70, 71, 72, 74, 75,
76, 89, 90, 91, 92, 96, 105];
for i=1:13
q=s(:,i);
m(1)= q(4);
m(2)= q(5)+ q(6);
m(3)= q(7);
m(4)= q(8);
m(5)= q(9);
m(6)= q(12)+ q(13);
m(7)= q(14);
m(8)= q(16);
m(9)= q(17)+q(18);
m(10)= q(21);
m(11)= q(25);
m(12)= q(26);
m(13)= q(29)+q(30);
m(14)= q(33);
m(15)=
q(31)+q(34)+q(36)+q(37)+q(38)+q(40)
+q(41);
m(16)= q(39);
m(17)= q(42);
m(18)= q(47);
m(19)= q(48);
m(20)= q(56);           %% no data
m(21)= q(57);
m(22)= q(61);
m(23)= q(68);
m(24)= q(69);
m(25)= q(71)+q(76);
m(26)= q(86);
m(27)= q(87);
m(28)= q(90)+q(91)+q(94);
m(29)= 0;               %% no data
m(30)= q(92);
m(32)= q(95)+ q(96)+ q(97)+
q(98)+q(99);
m(33)= q(100);
m(34)= q(107);
m(35)= q(114);
m(36)= q(117);
m(37)=
q(129)+q(134)+q(139)+q(140)+q(141)+
q(142);
m(38)= q(142);
m(39)= q(143);
m(40)= q(144);
m(41)= q(151);
m(42)= q(152)+q(153);
m(43)= q(156);
m(44)= q(161);
m(45)= q(164);
m(46)= 0;               %% no data

m(47)= q(166);
m(48)=
q(172)+q(173)+q(174)+q(175)+q(176);
m(49)= q(179);
m(50)= q(181);
m(51)= q(182);
m(52)= q(184);
m(53)= q(186);
m(54)=q(190)+q(191)+ q(194)+q(195);
m(55)= q(200);
m(56)= q(207);
m(57)= q(455);
m(58)= q(216);           %%
m(59)= q(222);           %%
m(60)= q(221)+q(223)+q(224);
m(61)= q(225);
m(62)= q(309);
m(63)= q(360);
m(64)= q(379)+q(380)+q(381)+q(382);
m(65)= q(383)+q(384);
m(66)= q(386);
m(67)= q(387);
m(68)= q(390);
m(69)= q(395);
m(70)= 0;
m(71)= 0;
m(72)= 0;
m(73)= q(397);
m(74)= 0;               %%
m(75)= q(401);
m(76)= q(406);
m(77)= q(410);
m(78)= q(416)+q(419);
m(79)= q(424);
m(80)= q(427);
m(81)= q(436);
m(82)= q(442);
m(83)= q(449);
m(84)= q(468);
m(85)= q(478);
m(86)= q(481);
m(87)= q(487);
m(88)= q(477)+q(486)+q(490);
m(89)= q(507);
m(90)= q(508);
m(91)= q(509)+q(510);
m(92)= 0;               %% no data
m(93)= q(514);
m(94)= q(518);
m(95)= q(529)+q(533);
m(96)= q(537)+q(574);
m(97)= q(575);
m(98)= q(609);
m(99)= q(619);
m(100)=
q(630)+q(631)+q(632)+q(637)+q(638)+
q(644);
m(101)= q(650);         %%
m(102)= q(651);
m(103)= 0;             %% no data
m(104)= 0;             %% no data
map=[map m'];
end

```

```

c=zeros(105,13);
c(1:104,:)=map;
for i=1:13
a=diag(IOS(:,((i-1)*105+1):i*105));
b=c(:,i);
e=corr(a,b);
d=[d e];
end
d=d';
for i=1:13
e=diag(IOS(:,((i-1)*105+1):i*105));
f=[f e];
end
g= sum(c)'; % this is the sum
of number of working people in each
year
r= sum(f)'; % this is the sum
of internal montary transactions of
each year
%% y1993 is de naamgeving voor IO
tabel matrix voor jaar 1993
%% d93 is de naamgeving voor WP in
een vector in de volgoede van
SBI93
%% map is een vector die de mapping
van WP op IO doet

```

---

## SectorsInf.m

```

% this function provides, by TRANS
selected, activity clusters
monetary transactions derived from
I/O table, inflation correction is
included, and it also generates the
Xcel files
Inflation= [0.7, 1.1, 2.5, 3.9,
3.7, 2.1, 2.7, 2, 2.1, 2.2, 2, 2.2,
2.6, 4.5, 3.4, 2.1, 1.2, 1.7, 1.1,
1.6];
Inf= (Inflation/100 + 1);
jr=[1987, 1988, 1989, 1990, 1991,
1992, 1993, 1994, 1995, 1996, 1997,
1998, 1999, 2000, 2001, 2002, 2003,
2004, 2005, 2006, 2007];
IO=[t1988, t1989, t1990, t1991,
t1992, t1993, t1994, t1995, t1996,
t1997, t1998, t1999, t2000, t2001,
t2002, t2003, t2004, t2005, t2006,
t2007];
IO(isnan(IO))=0;
l=t1987;
l(isnan(l))=0;
DC=[]; % Totaal kolommen 1-104
DE=[]; % Consumptieve bestedingen
door huishoudens
DM=[]; % Totaal kolommen 105-114
t=[];
a=1;
z=[];
IOC=[];

```

```

IDC=[]; % Totaal kolommen 1-104:
Water, Finance, Onderwijs, Energy,
Zorg, Telecom en post, overig
IDE=[]; % Consumptieve bestedingen
door huishoudens: Water, Finance,
Onderwijs, Energy, Zorg, Telecom en
post, overig
IDM=[]; % Totaal kolommen 105-114:
Water, Finance, Onderwijs, Energy,
Zorg, Telecom en post, overig
IIDC=[]; % Totaal kolommen 1-104:
Government, Real Estate,
Construction, Water, Finance,
Onderwijs, Energy, Zorg, Telecom en
post, overig
IIIDE=[]; % Consumptieve bestedingen
door huishoudens: Government, Real
Estate, Construction, Water,
Finance, Onderwijs, Energy, Zorg,
Telecom en post, overig
IIDM=[]; % Totaal kolommen 105-114:
Government, Real Estate,
Construction, Water, Finance,
Onderwijs, Energy, Zorg, Telecom en
post, overig
IIIDC=[]; % Totaal kolommen 1-104:
Government, Real Estate,
Monstruction, Water, Finance,
Onderwijs, Energy, Zorg, Telecom en
post, overig
IIIDE=[]; % Consumptieve bestedingen
door huishoudens: Government, Real
Estate, Monstruction, Water,
Finance, Onderwijs, Energy, Zorg,
Telecom en post, overig
IIIDM=[]; % Totaal kolommen 105-114:
Government, Real Estate,
Monstruction, Water, Finance,
Onderwijs, Energy, Zorg, Telecom en
post, overig
for i =1:20
a = a * (1/Inf(i));
t = IO(:,i*117-116:i*117)*a;
z = [z t];
end
IOC = [1 z];
for i =1:21
t = IOC(:,i*117-116:i*117);
h = t(:,107);
DC = [DC h(2:105)];
h = t(:,109);
DE = [DE h(2:105)];
h = t(:,117);
DM = [DM h(2:105)];
end
IDC=[DC(50,:); sum(DC(96:97,:));
DC(74,:); sum(DC)- DC(50,:)-
sum(DC(96:97,:))- DC(74,:) ]; %
Energy, Zorg, Telecom en post,
overig
IDE=[DE(50,:); sum(DE(96:97,:));
DE(74,:); sum(DE)- DE(50,:)-
sum(DE(96:97,:))- DE(74,:) ]; %

```

```

Energy, Zorg, Telecom en post,
overig
IDM=[DM(50,:); sum(DM(96:97,:));
DM(74,:); sum(DM)- DM(50,:)-
sum(DC(96:97,:))- DM(74,)] ; %
Energy, Zorg, Telecom en post,
overig
IIDC=[DC(51,:); sum(DC(75:77,:));
sum(DC(93:95,:)); DC(50,:);
sum(DC(96:97,:)); DC(74,:);
zeros(1,21)];
t= [sum(DC)- sum(IIDC)];
IIDC(7,:)=t; % Water, Finance,
Onderwijs, Energy, Zorg, Telecom en
post, overig
IIDM=[DM(51,:); sum(DM(75:77,:));
sum(DM(93:95,:)); DM(50,:);
sum(DM(96:97,:)); DM(74,:);
zeros(1,21)];
t= [sum(DM)- sum(IIDM)];
IIDM(7,:)=t; % Water, Finance,
Onderwijs, Energy, Zorg, Telecom en
post, overig
IIIDE=[DE(51,:); sum(DE(75:77,:));
sum(DE(93:95,:)); DE(50,:);
sum(DE(96:97,:)); DE(74,:);
zeros(1,21)];
t= [sum(DE)- sum(IIIDE)];
IIIDE(7,:)=t; % Water, Finance,
Onderwijs, Energy, Zorg, Telecom en
post, overig
IIIDC=[sum(DC(89:92,:))+ DC(99);
sum(DC(78:79,:)); sum(DC(52:57,:));
DC(51,:); sum(DC(75:77,:));
sum(DC(93:95,:)); DC(50,:);
sum(DC(96:97,:)); DC(74,:);
zeros(1,21)];
t= [sum(DC)- sum(IIIDC)];
IIIDC(10,:)=t; % Government, Real
Estate, Construction, Water,

```

```

Finance, Onderwijs, Energy, Zorg,
Telecom en post, overig
IIIDM=[sum(DM(89:92,:))+ DM(99);
sum(DM(78:79,:)); sum(DM(52:57,:));
DM(51,:); sum(DM(75:77,:));
sum(DM(93:95,:)); DM(50,:);
sum(DM(96:97,:)); DM(74,:);
zeros(1,21)];
t= [sum(DM)- sum(IIIDM)];
IIIDM(10,:)=t; % Government, Real
Estate, Construction, Water,
Finance, Onderwijs, Energy, Zorg,
Telecom en post, overig
IIIDE=[sum(DE(89:92,:))+ DE(99);
sum(DE(78:79,:)); sum(DE(52:57,:));
DE(51,:); sum(DE(75:77,:));
sum(DE(93:95,:)); DE(50,:);
sum(DE(96:97,:)); DE(74,:);
zeros(1,21)];
t= [sum(DE)- sum(IIIDE)];
IIIDE(10,:)=t; % Government, Real
Estate, Construction, Water,
Finance, Onderwijs, Energy, Zorg,
Telecom en post, overig
% xlswrite('IO_IDM_Totaal kolommen
105-114(1987-2007)Inflatie
gecorrigeerd.xls',IDM,'sheet1',
'A1');
% xlswrite('IO_DC_Totaal kolommen
1-104(1987-2007)Inflatie
gecorrigeerd.xls',DC,'sheet1',
'A1');
% xlswrite('IO_DE_Consumptieve
bestedingen door huishoudens(1987-
2007)Inflatie
gecorrigeerd.xls',DE,'sheet1',
'A1');
% xlswrite('IO_DM_Totaal kolommen
105-114(1987-2007)Inflatie
gecorrigeerd.xls',DM,'sheet1',
'A1');

```