Chapter 13
The Significance of User Involvement in Smart Buildings Within Smart Cities

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13.1 Intelligent Concepts, Content and Context

No universally accepted definition of smart building exists. Smart city concept or phenomenon can be approached from various definitions as well. However, a common nominator of all definitions of smart environment is to ensure benefits to the users. Built environment is a venue for all activities and technology is an enabler for provision of smart environment that adds on knowledge to the benefit of users' intelligence.

Next, the definitions of intelligent buildings and smart cities pave our way to descriptions of use cases in current smart built environment. In the following Chapters, the user involvement is seen as an important unused potential for an ever more connected society on smart innovations.[1] There the user does not play the role of feedback or preference provider alone or not even the role of an innovator but acts as an individual who understands and uses one's legal rights to own data—or is served as such a client. The future of smart environment that has been started to happen already will end this article.

The very first intelligent buildings can be named in the 1980s but since then the cases of such buildings are numerous. The latest development in European innovation aims to permanent changes in employing new technology in society and increases the number of uses of advanced technologies all over it. Recent technological advancements and related challenges do not present themselves under laboratory conditions. Still testing and validation phases are needed before digital

[1]A process in which new ideas (technologies, designs, procedures, etc.), and combinations of them, bring about changes in (sub) systems like supply chains, markets, urban regions, etc. This process can be incremental, radical or even disruptive.

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eco systems are ready for commercialisation and global deployment. It is necessary to conduct both laboratory and further extensive large-scale field testing in true environment in cooperation of industry or public sector and academia. The latter ones are often called as living labs.

There are already different lists of smart or smarter cities. At time being, one cannot help considering them representing a very welcomed hype of the concept and full scale implementations limit into a special suburban or a special city service such as intelligent transportation for example.

13.1.1 First Milestones

Intelligent building concept was born in 1980s and development of the more effective ways of using information started from 1970s and the World Wide Web was ready to go in 1992. In information age, communication and information technology dominates chasing after speed in computing the ever-increasing amount of data. This time period, as well as knowledge age, can be considered a period when the human mind is employed as a production factor in ever more extend or alone. Very recent technological advancements have led to the creation of distributed wireless sensor (and actuator) networks that are candidate technologies for improved and networked monitoring and controlling of critical infrastructures and operating embedded technology.

Cloud-based information fusion and knowledge management systems[2] provide access to wider content of open data[3] bases and social media. Or data on cloud can be linked to company intranets or interoffice registers, either role-based or content-based depending on the access rights of the user. As well, data management can be personalised or it concerns daily digital living of a family. Intelligent building concept has spread out to the city and society. IT[4] giants such as MicroSoft, Google or Amazon look for new niche in digitalized built environment industry as well as software developers who sit in startups. They intend to enter the market that has been traditionally occupied by real estate developers, designers, constructors or asset, property and facilities management companies etc. who have not expanded their business to wider or open concepts.

Academia, industry and education work for research and innovation in smart technology. For example, the Intelligent Building Master course at the Reading University has a holistic transdisciplinary approach while for example the former Intelligent Building studies at Temasek Polytechnic in Singapore took the

[2]Duhon [28]: 'Knowledge management is a discipline that promotes an integrated approach to identifying, capturing, evaluating, retrieving, and sharing all of an enterprise's information assets. These assets may include databases, documents, policies, procedures, and previously un-captured expertise and experience in individual workers'.

[3]Data that can be freely used, reused and distributed by anyone.

[4]Information technology

technology push approach. The focus in education has turned towards smart buildings management for example at Carnegie Mellon University in Ohio USA and also at Temasek Polytechnic in Singapore.

The CABA Continental Automated Buildings Association (established in 1988; www.caba.org/) have had since 2010 the CABA Research Program. The scope of it includes market research for both large building technologies and home systems (e.g. 11 publications in 2015). The latest tendency has been that the earlier intelligent building professional and networking organisations have become less active and new ones are evolving such as Memoori Business Intelligence Ltd or ABI Research for example and other information services on cloud.

European and global cities and city regions have created collaborative RTDI-networks (Research Technical Development and Innovation) such as Euro-Cities, Smart Cities and Innovative Regions. The European Innovation Partnership on Smart Cities and Communities (EIP-SCC 2016), European Network of Living Labs (ENoLL) are examples of European-wide collaboration platforms with global reach connecting up innovative ecosystems in industry, and open city or regional context to collaborate in RTDI.

Roughly said, the European definitions of intelligent building highlight the user involvement (cf. the PAS Standards in Section of Standardization) in comparison with the USA and Asian approaches (Himanen [45], pp. 57–70, Onaygil and Guler [70]). In the very beginning of the introduction of the intelligent building concept, Japanese put emphasis on human quality in building and expanded the concept of smart building into the city by TRON project already in 1984.

Despite the importance of integration factor in the first definitions of intelligent building, the conferences organised by the North American based Intelligent Building Institute in 1980s and 1990s discussed user involvement as an important issue—and buildings in a wide context of the city. For example, Mr. Johnson See from Kone Elevators listed the technological, operational, communication and environment aspects in the concept of intelligent building at the 'Seminar on Intelligent Buildings for the Next Millennium' in 1997 in Singapore at Temasek Polytechnic.

At the same conference, Dr. W Green from Consutel Australia named the first generation of intelligent buildings as Technology-Centred Approach and originated from the early 1980s, and the next generation as Organisation-Centred from the late 1980s. He saw that the People-Centred Approach had started already in the early 1990s. He listed five views of stakeholder groups to intelligent building

- *'Public: an exciting and familiar icon representing the company,*
- *Employees: an inspiring, efficient, comfortable and secure workplace,*
- *Owners: a statement of company stature, and a sound investment,*
- *Tenants: an attractive, prestigious, cost-effective business location,*
- *Building managers: an energy efficient and easily managed building'.*

The majority of definitions of smart solutions do not touch the meaning of the human intelligence in this context, except the definition of the author [45] defining the forms of building intelligence based on human intelligence by Gardner (1983 [42]).

Onaygil and Guler [70] conclude that 'One view is that intelligence is considered to be an innate, general cognitive ability underlying all processes of conventional reasoning'.

The use of building intelligence is expected to enable for example

- Energy efficiency without losing indoor environmental comfort,
- Meet space optimisation and expectations of and flexible space design and interplay between private and common space,
- Increased performance of building technology due to integration and low running costs [75],
- Increased working performance of the occupant activity and decreased need to travel,
- Improved comfort level due to amenities, active structures and home automation and
- Well-being thanks to ambient assisting or independent living technologies.

The benefits of smart city are expected to realise via sophisticated use of data which will make the field-specific silos collapse and the society open and transparent, and further on increase possibilities to individual citizens to be active in society. Influences are unpredictable in economy and politics, which we share and on which we have agreed common rules.

To gain better energy efficiency has been in focus in particular, in the European energy policy and consequently in European innovation policy. Integrated intelligent technologies in built environment have foreseen an important tool while buildings and building sector as well as transport use most of the energy and Europe is highly depend on imported energy.

The importance of keeping up well-being of the growing elderly population has pushed forward the development of eHealth (defined by World Health Organization WHO as use of ICT for Health or mHeath as the practice of medicine and public health supported by mobile devices by Wikipedia). In this context, smart housing works as an aided tool and as a smart environment for embedded technology or as a platform for the digital ecosystem. Also, the national policies on social affairs and health consider the use of technology important, for example, in such countries as the United Kingdom, Finland or the Netherlands [63, 79]. The Digital Agenda[5] targets all citizens in this respect of digitalization and considers it as a tool for good quality of living (Digital Agenda [24]).

In summary, the focus in the most advanced European buildings and cities has been on digital solutions of passive energy management and of assisted technology beneficial for all. Recently, an integrated communications infrastructure has started to have impact on intelligent building and smart city development within the innovations of Internet of Things[6] (IoT) technologies. The active end-user involvement has

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[5]Set within the seven pillars of the Europe 2020 Strategy which sets objectives for the growth of the European Union (EU) by 2020.

[6]The Internet of Things (IoT) refers to the ever-growing network of physical objects that feature an IP address for internet connectivity, and the communication that occurs between these objects and other Internet-enabled devices and systems.

not yet turned the representatives from building and real estate industry or the city councils on to smart environmental solutions although it has become increasingly important in the competition in attractive and successful cities and regions and when pushed forward from such concepts as servitisation[7], collaborative[8] or digital economy—the latter one still in search of its final form or course.

13.1.2 Intelligent Building Integrating Technologies

The definition of the intelligent building as a building of integrated technologies was introduced by the Intelligent Building Institute Foundation (I.B.I. [50]):

> *'An intelligent building is one which provides a productive and cost effective environment through the optimisation of its four basic elements ñ systems, structure, services, management and the inter-relationship between them. Intelligent buildings help building owners, property managers, and occupants realize their goals in the areas of cost, comfort, convenience, safety, long term flexibility, and marketability. There is no intelligence threshold past, which a building 'passes' or 'fails'. Optimal building intelligence is the matching of solutions to occupant needs. The only characteristic that all intelligent buildings have in common is a structured design to accommodate change in a convenient, cost-effective manner.'*

The idea of integrating the technologies in a wider context popped up after the Internet became a main stream technology in daily work and living. Bluetooth was introduced and the blue ideas of using Internet for integrating everything by such technologies as RFID (Radio Frequency Identification) tags in all products, use of IP addresses and signaling for surveillance although the reach of it in the first place was short.

13.1.3 Technology Push Approach in Smart Buildings

The recently established Smart Building Institute (SBI; www.smartbuildingsinstitute.org/) represent the USA type definition of smart building in their recently published book (Sinopoli [81]):

[7]The delivery of a service component as an added value, when providing products. Servitisation supplements the traditional product offerings. The service is usually delivered via mobile devices or internet.

[8]Also known as shareconomy, collaborative consumption or peer economy, a common academic definition of the term refers to a hybrid market model (in between owning and gift giving) of peer-to-peer exchange. The collaborative economy is defined as initiatives based on horizontal networks and participation of a community. It is built on "distributed power and trust within communities as opposed to centralized institutions, blurring the lines between producer and consumer.

> *"Smart Buildings Systems for Architects, Owners and Builders is a practical guide and resource for architects, builders, engineers, facility managers, developers, contractors, and design consultants. The book covers the costs and benefits of smart buildings, and the basic design foundations, technology systems, and management systems encompassed within a smart building. Unlike other resources, Smart Buildings is organized to provide an overview of each of the technology systems in a building, and to indicate where each of these systems is in their migration to and utilization of the standard underpinnings of a smart building."*

They highlight that the technology is the enabler of performance of the building for all stakeholders, but do not especially define factors that create the end-user benefits. Still, one cannot deny that the USA type definition does not apply in Europe as well. Especially the commercial sector, component providers and systems consultants favour it. As well, the Smart Homes Foundation's definition for home sector represented the same approach (van Berlo [15]).

It has been typical that smart building to address smart building concept as integration of the number of systems and provides overall management through one system platform. The idea is that smart buildings are designed for the efficiency of all components of a building, such as lighting, monitoring, safety and security, emergency systems, heating, ventilation and air conditioning systems and car parking management. Smart building technologies lengthen the life span of a building by identifying problems as and when they occur and taking the required corrective measures. It seems that the one system platform strategy—as a killer application by one operator—has not been so far a success in sales.

In 2002 Realcomm published an article on how networks will connect building processes [78].

Despite the high potential of an integrated communications infrastructure, building automation and management systems (BAS/BMS) still consider new entrants leveraging the connectivity of BAS/BMS systems and the SaaS business model [2].

13.1.4 Large Intelligent Buildings

Intelligent Buildings were advocated by UTBS Corporation (United Technology Buildings Systems Corporation) in the USA in 1981, and became a reality in July, 1983 with the inauguration of the City Place Building in Hartford, Connecticut USA (Onaygil and Guler [70]). The UTBS Corporation was responsible for controlling and operating such shared equipment as air-conditioning equipment, elevators and disaster prevention devices. The company further provided each tenant with communication and shred tenant services, such as office automation services, using local area networks (LANs), digital private automatic branch exchanges (PABXs) and computers.

Intelligent Buildings Institute's definition focused on the lack of integration of technologies. For example, architects and engineers at Foster + Partners fulfilled the demand by designing and managing the construction Hongkong and Shanghai Bank Headquarters building in Hong Kong, China in 1979–1986 (Foster [40]). At that time, it was considered one of the most advanced office towers also in the sense of integrated building and office automation, which was installed innovatively into the structures together with the building service facilitation. Foster + Partners introduces themselves today as '… the best design comes from a completely integrated approach from conception to completion and the design teams are supported by numerous in-house disciplines, ensuring the knowledge base to create buildings that are environmentally sustainable and uplifting to use'. One of the Fortner + Partners' designs is a commercial skyscraper, 30 St Mary Axe (widely known informally as The Gherkin) in London in 2013. In addition to its neo-futuristic architecture, the building represents advancement energy efficient and green building carried out by sophisticated building service technology (as, e.g. renewed natural ventilation) and structures.

Many projects have been realised on remarkable office buildings following the similar path than that of the Foster + Partners' example from integrated technology towards sustainability[9] (cf. more Section Energy Efficient Building) and advanced office layout for knowledge work place (cf. more Section User-Oriented Intelligent).

Integrating the design and construction phases close together is a trend to gain more efficient construction projects in time and money (Kruus et al. [53]). It has created new alliances between designers and construction companies.

Another interesting example of the progress from the very first intelligent buildings to today is the Nippon Telegraph and Telephone Corporation head office building buit in the 1980s in Tokyo. It had several floors preserved for servers of telecommunication services provided by the company. Similar situation was for example in Helsinki Finland with the Elisa Oyj's[10] head office, which was designed after the concept of intelligent building in 1997. Soon after, the floors of equipment have become insufficient to satisfy the increased demand for communication capacity in any location. They were replaced by (1) distributed technology in national fibre networks or (2) the huge telecenter buildings facilitating communication in cloud and operated by IT giants such as Google, Cisco. Due to the sensitive apparatus and huge heat load their operation causes demand for the cold or cool climatic condition and earthquake resistance which are favourable qualities for the location of such buildings. As well, the owners of telecenters prefer locations in countries with stabile political situation for the sake of data security.

Despite the huge advantage of the use of cloud-based technologies, the construction sector continues its tradition in practice and stick to the IT islands. Despite the potential of digital economy exists. The author has recently (2015) come across

[9] A multifaceted property that describes the extent to which social, economic and environmental objectives are in balance; that economic activity is not declining, that non-renewable resource throughputs are minimised and that society has high capital and is cohesive, equitable and inclusive.

[10] previously Elisa was Helsingin Puhelin Oy originated from a company established in 1882.

with companies in Denmark, Norway and Finland providing smart building management technology in cloud, who report that they can find few customers but the idea does not yet fly—there is largely interest (as towards free uploads) but majority of the market those who are interested do not buy. The market potential in digitalisation of building sector is huge and that promise keeps the providers come and go, or trying again and again with better approach to technology and customer needs.

Academia, industry and education work for research and innovation in smart technology. Further on, the inter-sectorial and multidisciplinarily integrated approach is still to come while for example the smart building market research report together with Global Forecast to 2020 by Markets and Markets [59] outlines in a relatively limited and technology-push-oriented manner that the global smart building market has been segmented into building automation system, networking technologies, applications and regions.

- Building automation systems include physical security, BEMS, communication technology, and parking management system.
- Networking technologies have been segmented into bus technology, power line technology and wireless technology.

The applications that use the smart building services are commercial buildings, industrial, institutional, residential, hospitality, hospitals, airports and others. This market has been further segmented into the regions of North America, Europe, APAC, MEA and Latin America.

The major players of smart building market according to Markets and Markets [59] are ABB, Cisco, Delta Controls, Schneider Electric, Siemens, IBM, General Electric, Johnson Controls, Accenture and Honeywell. However one can ask if these companies are players of the market in smart building or rather the market of such areas as building automation, facilities management or building maintenance? Markets and Markets [59] prognoses that the global smart building market is expected to reach $36398.7 Million in 2020 from $7260 Million in 2015, at a CAGR[11] of 38.0 % during the forecast period.

Many of the above-mentioned companies are originated from building automation business or they are IT giants as Cisco or IBM, of whom the latter one has just recently launched together with Carnegie Mellon University First Cloud-Based Analytics Partnership for Smarter Buildings. It heads also to Smarter Cities within its Smarter Planet initiative (www.ibm.com/smarterplanet/us/en/). Similarly, Ericsson approaches the wider concept of smart environment by the Smart Metering as a Service (SMaaS; www.ericsson.com) which is a complete end-to-end smart metering business process outsourcing solution operated. On the

[11]The Compound Annual Growth Rate (CAGR) is the mean annual growth rate of an investmentover a specified period of time longer than one year.

other hand, for example Honeywell has informed that they stick to the smart building research, development and innovation (in 2014).

The module of building automation which enables the building managers easily adjust the system operation is not a norm of the building automation installation—most probably partly due to the prizing and operational costs of the unit. A user study shows that the building manager, sitting in an office building, and available even in person, was the most favourable form of informing ones wishes on indoor air quality in the end of 1990s (Himanen [45]). Today, the response could be different after we are used to the vivid usage of social media. Nevertheless, the company gave up employing the building managers, after a relatively short period of time (roughly 2 years), in the intelligent building where the study was carried out.

13.1.5 Smart Housing

To integrate the in-house technologies and their operations proves of the technology push approach rather than user demand-driven approach. Also, the development of smart cities has followed this approach of technology push. Actually, the concept of integrated technologies in intelligent building expanded soon to the city context—starting with the TRON project as early as in 1984 in Japan by Professor Ken Sakamura of the University of Tokyo (Anon [7], Lehto[12] [55] and [56]).

The TRON house introduced several advanced technologies for kitchen appliances and their integration into the interior architecture and structural design as well as for storages and active furniture (cf. Lehto 1990a and Lehto 1990b). After the TRON project several demonstration projects have been carried out and show houses built. Among the first ones are such as: INTEGER HOUSE in United Kingdom (1998), ARKKIMEDES HOUSE in Finland in a smart housing fair area (1991), A*STAR house at the National University Singapore campus (2005), and many others, e.g. in the Netherlands, Germany or Canada.

In housing market, there are innumerable commercial applications that represent automation which can be considered as part of the integrated smart home idea such as integrated building services for energy efficiency or home automation, (remote) smart metering, safety and alarm systems (presence and video surveillance), lighting controls, universal remote controls for in-home apparatus, home theatres, smart kitchen appliances, etc. As the modern home integrators run on mobile apps or in Internet they are replacing the old buses and system dependent control units.

Many relative simple features of automation might be missing from housing as for example the home heating and cooling control does not necessarily comprise controls provided by outdoor temperature sensors, not to mention, other outdoor-air qualities, although the vision of smart house already in 1980s comprises the ability

[12]The author (under previous name)

to protect the residents (e.g. by shutting the windows automatically) from impurities from a dangerous release due to failure in the neighboring manufacturing process for example, or increased pollution or pollen level in outdoor air.

Still, only the luxury homes take more sophisticatedly advantage of the smart home potential and the solutions are often tailored for the residents.

According to a new market research report (Markets and markets [60] the smart home market is expected to grow at a CAGR of 17 % between 2015 and 2020, and reach $58.68 billion by 2020. The study characteristics are

- The global smart home market has an exhaustive product portfolio. The smart homes market has been segmented by product into energy management systems, HVAC control, entertainment control, security and access control. The energy management system is further segmented into smart devices and lighting control solutions. Different security and access control product solutions included in the report are intrusion detection system, video surveillance, motion sensors, touch screen and keypads.
- The smart homes market is split into four regions: North America, Europe, APAC, and RoW. North America includes the U.S., Canada, and Mexico, while Europe is divided into the Germany, France, the U.K., and others; APAC smart homes market includes China, Japan, India, and others while RoW is divided into the Latin America, the Middle East and Africa.
- The study comprised the competitive landscape of main players, which covers key growth strategies followed by all prominent players. Some of the big players profiled in the market report are Siemens AG (Germany), Schneider Electric S.A. (France), ABB Ltd. (Switzerland), Ingersoll-Rand PLC (Ireland), Emerson Electric Co. (U.S.), Legrand S.A. (France), Crestron Electronics, Inc. (U.S.), Lutron Electronics, Inc. (U.S.), Control4 Corporation (US), and more.

Markets and markets [60] had a technology push approach to smart housing while the number of companies looking smart homes as a provider or enabler of amities or assistance for daily easy living of residents has not dominated the business. Assistance in cleaning, cooking, dish washing, laundry, etc. rely on smart technology by home appliance providers who seem not to be part of the above-mentioned study, but are global players in the market of smart technology.

Markets and markets [60] foresees the future of smart home technology promising as they conclude:

> *'Traditional home automation devices were designed to control systems within a house and within a limited range of connectivity; however, with recent developments across different areas of connectivity of appliances and devices, … including mobile connectivity features, an integral component of smart homes provided by device manufacturers; and compatible communication protocol and technology based products offered by Internet Service Providers. Even though the concept of smart homes has been in existence for a long time, the market has witnessed a profound growth, mainly, during the last five years. The smart homes market is highly fragmented and expected to get consolidated. The smart homes service providers are beginning to gain traction in the marketplace, and we could see more smart homes technology players entering the market before an inevitable consolidation occurs.'*

This promise of Markets and markets [60] can be considered as an opportunity for startups competent in cloud technology. At time being, they are foreseen to be responsible for the ongoing future digitalization of electronic service sector in a wide sense comprising smart homes but by no means overlooking the skills and potential of startups to perform in any sector.

In many countries, third sector works for developing and implementing technology for independent living. In the Netherlands, both the elderly organizations as the smart house associations have worked for encouraging use of smart house technology within elderly housing, since 1990s (cf. Expert Center for Smart Technology and Smart Living (www.smart-homes.nl); previously Smart Homes Foundation. Still, van Berlo [11] concludes that we know how to build smart houses and about AAL technology (Ambient Assisted Living, cf. AAL [1]), but we may not understand why older people are not necessarily buying it.

Growing numbers of elderly population has pushed forward the development of smart housing. The European Commission has strongly encouraged the use of technology for independent living both by various policy initiatives: the EIP-AHA (European Innovation Partnership on Active and Healthy Ageing) initiative or the Digital Agenda action plan 2013, and for example such funding instruments as the EU Horizon 2020[13] Health, Demographic Change and Wellbeing Programme or the AAL Joint Programme [1] implemented by both the EU and EUREKA Network (www.eurekanetwork.org).

In addition, the Eureka Eurostars programme[14] (www.eurostars-eureka.eu) provides funding for SMEs (small and medium-sized enterprise, European Commission [38]) without limiting the subject and thus, it funds projects on smart housing and gerontechnology among others. Similarly, within the EU Horizon 2020 the MSC programme[15] does not limit the study subject and comprises scientific projects which has focused recently relatively often on smart housing. Smart housing is also part of the calls related to energy efficiency and smart city (cf. Sections on Energy Efficient Building and Smart Grid).

13.1.6 Energy Efficient Building

As mentioned Foster + Partners, as well as leading engineering and architects' offices have developed their design towards energy efficiency or sustainability which rely on advanced integrated technologies, in building automation in

[13]The European Commission Framework Programme for Research and Innovation 2013–2020.

[14]The Eurostars Programme (2008–2013) and the Eurostars-2 Programme (2014–2020) Co-funded by EUREKA member countries and the EU Horizon 2020 Research and Innovation Programme.

[15]The Marie Skłodowska-Curie actions (MSCA) provide grants for all stages of researchers' careers—be they doctoral candidates or highly experienced researchers—and encourage transnational, intersectoral and interdisciplinary mobility (cf. http://ec.europa.eu/programmes/horizon2020/en/h2020-section/marie-sklodowska-curie-actions).

particular. This trend has been supported by the development of energy certification by the commercial energy labels such as BREEM, LEEDS, Green Office or Gold Power by WWF, etc. (e.g. the Energy Labelling Directive (2010/30/EU), Himanen et al. [47], as well as, governmental initiatives, global bodies as for example the United Nations Industrial Development Organization (UNIDO) and the funding schemes of the European Commisision (EU) Framework Programmes for research and innovation (FPs), National Science foundation in USA (NSF [66]) and many others corresponding programmes.

Projects resulting in integrated commercial-scale solutions with a high market potential, in the field of energy, transport and ICT (Information and communication Technology) have been conducted since the EU Seventh Framework Programme (the EU FP7), starting in 1998. They focus on large experimental projects with advanced metering and experimental installations. They focus on study occupant experience when technology is in operation in true built environment, or in the context of Smart Cities Light House projects. Similarly, the EIT ICT Labs[16] promote smart energy efficiency, especially the action line Smart Energy Systems (SES). For example, one of the latest EIT Digital project calls was titled 'Intelligent Integrated Critical Infrastructures for smarter future Cities' (I3C).

The subject of energy efficiency has been in focus of the EU Framework Programmes from very beginning in 1984 and especially focused on the smart building and cities for example in

- the Programme of Energy-efficient Buildings (EeB) since 1990s till the current EU Framework Programme, Horizon 2020 where the implementation of the EeB programme has been executed since 2014 by the Executive Agency for Small and Medium-sized Enterprises (EASME)[17]
- the Earlier Intelligent Energy—Europe (IEE) programme in 2003–2007 (European Commission [37]).

13.1.7 Total Building Performance

Total building performance is an approach to integrated building service systems and keeping smart systems as enablers. The concept is in line with thinking behind the original intelligent building concept. The digital economy highlights the importance of the total building performance concept while demanding systems design of data flows and operational chaining across traditional limits in operational units.

[16]Founded in 2008, the EIT ICT Labs one of the Knowledge and Innovation Communities (KIC) at the European Institute of Innovation and Technology (EIT), www.eitdigital.eu. The EIT ICT Labs aims to create synergies between education, research, and innovation targeting results to be ready for commercialization.

[17]Set-up by the European Commission to manage on its behalf several EU programmes.

Assoc. Prof Lee Siew Eang is the pioneer in the total building performance studies. The Centre for Total Building Performance (CTBP) is a joint research centre of the Building and Construction Authority of Singapore (BCA) and the National University of Singapore (NUS). It is hosted by the Department of Building, School of Design and Environment.

The vision of the CTBP is to champion Total Building Performance R&D (Research and Development) and support the quest towards a quality and productivity driven construction industry. The research roadmaps are Research Programmes on

- Green and Energy Efficient Building
- Indoor Environmental Quality
- Building Performance Integration and Innovation
- Building Maintainability
- IT Design Decision Support Systems.

Interestingly in line with the idea of total building performance, the comparison of the intelligent office buildings with the other type high quality buildings showed stochastic remarkable difference in favour of intelligent buildings when the users evaluated the building performance although the differences in implementing the ICT or building automation between these two types of buildings cannot be found to be very clear (Himanen [45]). The survey covered several systems in addition to those based on ICT such as indoor air quality, indoor design, building mass, travelling, etc. The author suggests that the importance of the holistic approach in the intelligent office buildings design was a reason to the result favouring them, but further studies to prove the hypothesis is needed. As well, it turned out to be obvious that

- The research on intelligent office buildings have proved that neither one intelligent feature makes the building intelligent nor can any good quality substitute and even mitigate bad quality of building installations and properties.
- There is a reality of co-effecting factors telling to take care of good quality of all features for gaining the satisfactory results.
- Multidisciplinary[18] and inter-sectorial (or transdisciplinary[19]) innovation comprises both 'hard' technological disciplines and design criteria based on 'soft' sciences.

High-rises or tall buildings demand latest in any solution: structures, elevators, etc. Building process of them needs special attention in various phases of design as well as organization of property management for entire building life time. They can

[18] A problem is approached from several scientific or professional fields.

[19] A collaboration spanning multiple partners, both academic and non-academic as, to solve a common problem. Non-academic partners may include city officials, (non-) governmental agencies and offices, charitable organizations, companies, civil society, grassroots movements, etc. A synonym is inter-sectorial. Non-academic partners may include city officials, NGO's, companies, civil society, grassroots movements, etc.

be considered intelligent as such. Further information on tall building cases is found from:

- The Skyscraper Center, the Global Tall Building Database of the CTBUH (the Council on Tall Buildings and Urban Habitat, cf.
- List of tallest buildings and structures in the world can be found for example on Wikipedia.

Such new elements as commissioning or life-cycle procurements cover the whole building process as well.

If commissioning is quality control from the clients' point of view, the total building performance concept can be understood as the same as the inner quality control in manufacturing industry—that has been practiced there from the 1960s. Not the client as in the case of commissioning but the operators themselves within the building industry gain tools for improving their performance.

With the concept of integrated facilities management is understood that building automation is combined to the facilities management. Life-cycle procurements process covers the process from feasibility studies to the facilities management service provisions. The idea is to gain feedback that enables improvement in the performance of industry and makes it possible to serve their clients, the occupants of any built environment better than earlier.

13.2 Smart Integrated Urban Development

The current innovation of smart city has two focus areas: (1) the open city with public service accessibility to be discussed first and (2) the Smart Grid discussed that after. In addition, national information highways to enable the effective and smooth technological implementation of smart city innovations are discussed in Chapter of Future Potentiality. All these approaches have an end-user-oriented approach.

13.2.1 Smart City

Cities are the main driver of change in economic development and growth, knowledge and creative generation of production, innovation and overall liveability. The study of the European Environment Agency EEA [30] shows consistent evidence of

- A positive association between urban wealth and the presence of a vast number of creative professionals,
- A high score in a multimodal accessibility indicator, the quality of urban transportation networks (cf. Thulin [84]),

- The diffusion of ICTs (most noticeably in the e-government industry), and
- The quality of human capital.

Urban areas both face important sustainability challenges in social, economic and environmental issues and at the same time form an ideal setting to generate solutions. The Digital Agenda[20] proposes to better exploit the potential of ICTs in order to foster innovation, economic growth and progress. Among others, Caragliu et al. [17] have defined smart cities profiling the competitiveness of cities.

Smart cities are expected to become a sizable market with a large spending on smart cities technologies (cf. also Belissent [12], Bowerman et al. [14]). Real estate experts predict that smart cities will in the future be attractive to the educated, high salary knowledge work force and will therefore become profitable locations for real estate investors. The built environment is the core of the concept of smart city, however, the smart city is a wider concept

- According to the Smart City Council it comprises topics as Smart People (uses technology to make its citizens' lives better), Universal (e.g. open spaces for public use), Built Environment, Energy, Telecommunications, Transportation, Water and Wastewater, Waste Management, Health and Human Services, Public Safety, Smart Payments and Finance (Anon [5]).
- Mapping Smart Cities in the EU Study defined that a Smart City is one with at least one initiative addressing one or more of the following six characteristics: Smart Governance, Smart People, Smart Living, Smart Mobility, Smart Economy and Smart Environment (Manville [58]).

The ENSUF[21] [33] as well as, the European Innovation Partnership for Smart Cities and Communities (EIP) defines that smart city refers to cities in which ICT is increasingly pervasive and ubiquitous. They are cities whose knowledge economy and governance is being progressively driven by innovation, creativity and entrepreneurship. There digital technologies can be used to efficiently and run effectively by public services provision. Urban challenges cannot be separated from the regional and local setting in both the actual spaces and the institutions (the processes, practices and formal and informal rules). ICTs and data help to 'smartly' organise information flows in peoples' everyday life concerning e.g. energy, water, materials, food, goods, ideas, and in politics. Especially in building sector, the use of smart energy efficient applications are looked to reduce high energy consumption and green house gas emissions causing bad air quality. Mitigation of congestion by intelligent transport have similar effect.

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[20]One of the seven pillars of the Europe 2020 Strategy which sets objectives for the growth of the European Union (EU) by 2020.

[21]The ERA-NET Cofund Smart Urban Futures (ENSUF) was established by the Joint Programming Initiative (JPI) Urban Europe in order to initiate a transnational joint call for RDI proposals developing our knowledge of the urban condition and sustainable development through creation and testing of new methods, tools, and technologies required to overcome current economic, social, and environmental challenges. ENSUF is supported by the European Commission and funded under the Horizon 2020 ERA-NET Cofund scheme.

Social and open innovation focuses on transdisciplinary co-creation[22] of smart urban development which is understood to be about the connectivity, accessibility and integration of various systems, sectors, services, infrastructures and public institutions. Increased urban liveability is gained by linking academic, practical and local knowledge.

These positive associations clearly define a policy agenda for smart cities, although clarity does not necessarily imply ease of implementation. Lists of smart or smarter cities have appeared. The progress is rapid and smart cities can be found in any location. Next, a couple of them are shown as examples, especially while they also refer to the guidelines in the area (cf. PAS 181:2014).

Manville et al. [58] concluded that there are Smart Cities in all EU-28 countries (after the selection of factors for successful Smart Cities that have been detailed in the report), but these are not evenly distributed:

- Countries with the largest numbers of smart cities are the UK, Spain and Italy, although the highest percentages are found in Italy, Austria, Denmark, Norway, Sweden, Estonia and Slovenia.
- Smart City initiatives are spread across several characteristics, but most frequently focus is on Smart Environment and Smart Mobility. Geographically, there is also a fairly even spread, although Smart Governance projects are mainly seen in the Older Member States of France, Spain, Germany, the UK, Italy and Sweden. Also noteworthy is that some characteristics typically occur in combination, such as Smart People and Smart Living.
- How the cities perform in the context of their country's national priorities and political and socioeconomic circumstances, led to the selection of the six most successful cities for further in-depth analysis: Amsterdam (the Netherlands), Barcelona (Spain), Copenhagen (Denmark), Helsinki (Finland), Manchester (UK) and Vienna (Austria). In each of these, a number of initiatives were assessed, showing focus on transport, mobility and Smart Governance, including building technologies.

Cohen [19] created the Smart Cities Wheel with a global advisory committee in order to charge on the smartest cities in the world and listed up to 400 potential indicators of which 62 were selected for assessment. Cohen [20], [21] listed the 10 smartest and innovative cities in 2014

- in Europe: Copenhagen, Amsterdam, Vienna, Barcelona, Paris, Stockholm, London, Hamburg, Berlin, Helsinki and
- in the world: Vienna, Toronto, Paris, New York, London, Tokyo, Berlin, Copenhagen, Hong Kong, Barcelona with strong candidates which are runners-up in this first ranking, including Amsterdam, Melbourne, Seattle, São Paulo, Stockholm, and Vancouver.

[22]An approach where heterogenous actors collaborate to produce knowledge, instruments, technology, artefacts, policy, know-how, etc.

Mass deployment of smart city concept on national or international perspective will not be possible without widely accepted standards. The widely used technology standards are not enough in city- or region-wide context. Standardization at smart application level is just in infancy phase (cf. Section Standardization of User-driven Smart Environment). A much stronger effort should be dedicated in this area in the future.

13.2.2 Smart Cities Digital Ecosystem

Generally speaking, the Smart City infrastructure is a digital ecosystem consisting of networked sensors and actuators, mobile phones, wearable devices and other embedded devices of general and/or specific purpose, and, by extension, of all *smart* devices with capabilities of interconnection, computation, and a sort of interaction with their environment (Schaffers et al. [80]).

Majority of the elements for improved thinking of the performance of smart environment and technology are existing. Advanced information or energy efficiency, public eHealth, advanced teaching and learning, etc. are in pipeline accordingly, for example, under the innovation in the Smart Cities and Communities lighthouse projects (the Horizon 2020 Work Programme 2014–2015 and 2016–2017).

Social impact of the research and innovation and ethical aspects has grown in importance within the European Research Area. The need for business planning within the projects or the gendered innovation has popped up (Expert group "Innovation through Gender" et al [39]) as well as the open science initiative. As well, the innovation on platformization asks the end-user involvement for example by the Internet of Things Focus Area (European Commission [35]). The ambition is to foster the take up of IoT in Europe and to enable the emergence of IoT ecosystems supported by open technologies and platforms. It will be addressed through a complementary set of activities structured around Large-Scale Pilots (European Commission [36], cf. Airaksinen and Kokkala [3]).

A good number of various functions and automated processes associated with smart environment generate vast amounts of data. Availability of valuable data has created insights of making analytics part of a growing marketplace exist. Data acquisition, normalisation, prioritisation and action are issues associated with data analytics—comprising a critical step in creating a trustworthy and functional smart built infrastructure and society.

More recently, development of smart urban environment has started to take into account the emergence of platforms for Big data[23] and IoT, applications on artificial

[23]Big data is high-volume, high-velocity and/or high-variety information assets that demand cost-effective, innovative forms of information processing that enable enhanced insight, decision-making, and process automation.

intelligence and their impact on smart buit environment. For example, the projects (e.g. FIWARE[24]) and platforms (e.g. SOFIA2,[25] PlanIT OS™, City OS, SOUL, City Protocol, LifeEngine, etc.) for smart cities and buildings focus on interoperability of technologies:

- Advanced platforms for middleware, standards, protocols, interfaces, etc. are under development for building e-infrastructure.
- Virtualisation of user experiences by connected environment with increasing virtual elements, augmented realities[26] and (hyper) connected (linked data) artificial intelligences that are embedded into the built environment around us.
- Safe and easy adaptability and occupancy-based control of digital ecosystems are targeted.
- 3D data visualisation techniques as surveillance based on video or machine-vision, and monitoring and control.
- A safe software development environment for testing new applications or a large-scale simulation framework for supporting the strategic and tactical decision process on smart cities are needed in innovation.
- Ontologies coping with heterogeneity and large-scale infrastructures for efficient aggregation of devices and compose/utilize complex virtual devices (De et al. [23]).
- Scalability while the number of objects connected to IoT increases exponentially for example, via smartphones, PCs, tablets, connected cars and wearable devices. IoT will become the largest device market in the world including hardware, software, and installation and management services. For example, Google processes more than 24 petabytes of data per day, an equivalent volume to thousands of times all printed collection of the US Library of Congress. At such scale of data, the technological capabilities, our capability of exploiting the data and, more importantly, our capability of reasoning about these data will be overflowed (Escolar [34]).

[24]The FIWARE Acceleration Programme promotes the take up of FIWARE technologies among solution integrators and application developers, with special focus on SMEs and startups.

[25]SOFIA2 is a middleware that allows the interoperability of multiple systems and devices, offering a semantic platform to make real-world information available to smart applications (Internet of Things). It is multi-language and multi-protocol, enabling the interconnection of heterogeneous devices. It provides publishing and subscription mechanisms, facilitating the orchestration of sensors and actuators in order to monitor and act on the environment. Cross-platform and multi-device through its SDK, APIs and extension mechanisms that allow integration with any device. A software development kit (SDK or "devkit") is typically a set of software development tools that allows the creation of applications for a certain software package, software framework, hardware platform, computer system, video game console, operating system, or similar development platform.

[26]A form of virtual reality augmented reality is a direct or indirect view of a real-world environment in real time which elements are augmented by computer-generated sensory input as graphics, sound and video. The user's view is enriched by virtual objects usually to provide information about the real environment. Typical hardware components are: processors, input devices, display, sensors and smartphones.

According to the App Economy Forecasts 2013–2016 report the global app economy accounted for 18 % of the combined application (app) services and handset market. It is estimated that the value migrates from handsets to apps by 2016, when the app market will rise to 33 % of the combined market (Vision Mobile [90]). An effect of this growing trend is the demand of application developers that in 2013 was estimated to be 12.6 % of the global developer population and predictably, will continue growing. The developer tools provided by most of the mobile platforms as Android or iOS offer a simple yet powerful programming environment for writing code and facilitate that both developers and users may program applications themselves. Apps can be published and stored in some repository (e.g. GooglePlay) from which they can be downloaded. Software as a Service (SaaS) is an alternative to apps for delivering applications in the cloud.

13.2.3 Smart Grid

Smart Grid technology is expected to efficiently manage supply and demand of electricity and modernize the technologies for grids, distributed generation (including microgrids) and improve grid reliability. A smart electricity supply network uses digital communications technology

- Firstly, for detecting and responding digitally to quickly changing electric demand and increasingly intermittent electricity production, even in real time, and
- Secondly, for two-way communication between the utility and its customers.

The Smart Grid consists of controls, computers, automation, and new technologies and equipment working interoperable together. The transition towards increasingly renewable energy systems or hybrid energy supply systems in the building, for example, calls for novel techniques of operation and control in response to the changing power transmission and distribution networks. The Smart Grid is not just about utilities and technologies; it is about giving the consumer the information and tools he or she needs to make choices about energy use in a similar way as already we manage activities on cloud such as buying tickets.

Adviser in Electric Networks at Finnish Energy Industries, Ms Ina Lehto tells that the Smart Grid is a two dimensional matter.

- Firstly, by definition the electrical grid as such is built of the transmission and distribution lines and digital technology which allows monitoring the power load, and secures energy transmission under stable and secure conditions. Primarily, the grid has simply been built smart from the needs of power supply side. This can be understood as a Smart Grid—representing an unprecedented opportunity to evolve the energy industry into increased reliability, availability and efficiency that will contribute to our economic and environmental health.
- Secondly, these smart technologies can be employed as a platform for consumer services of various kinds; from provision of the informative electricity bill to

cooperation with the customer as an energy supply provider, for example, of extra energy yielded from solar panels or industrial processes. In this context, the electrical engineering for Smart Grid has best to offer to smart built environment technologies.

Further on, Lehto adds on that the grid can be made sensing along the load and use the smart metering technology for the two-way communication, as done in Finland and Sweden, for example. Smart metering is indeed a key to two-way communication that provides customers with possibilities to use and produce electricity intelligently while ensuring efficient operation of the electricity markets.

At time being the Smart Grid is evolving, piece by piece, before all the technologies will be perfected, equipment installed, and systems tested to work fully on line. Research and innovation projects within the Horizon 2020, for example, will generate full scale use cases while the calls ask proposals of solutions that will be demonstrated in large-scale pilots and validated in real life conditions, or on real data by simulations that will take a long enough period of time for ensuring credibility and consistency of conclusions. A set of technologies and solutions are expected to be demonstrated in an integrated environment; to enable demand response, Smart Grid, storage and energy system operating under stable and secure conditions, rather in the context of an increasing share of renewable energy sources in the electricity grid.

The EIT ICT Labs are active in Smart Grid innovation within action line Smart Energy Systems (SES). Similarly, the Eurostars joint programme projects comprise innovation in Smart Grid. The perspective of introduction the outcome of the Horizon 2020 innovation actions in the market is expected to happen in the coming years after the project. The time to market of the Eurostars project results is in maximum 2 years after the project completion.

During the transition period, it will be critical to carry out testing, technology improvements, consumer education, development of standards (e.g. CEN-CLC-ETSI M/490) and regulatory environment for privacy, data protection, cyber security, as well as, Smart Grid deployment, infrastructure and industrial policy (cf. the Smart Grid Task Force and its Experts Groups in the field of Standardization on http://ec.europa.eu/energy/en/topics/markets-and-consumers/smart-grids-and-meters/smart-grids-task-force).

The projects in the consumer response and cooperation may deal with

- Mechanisms and tools allowing consumers to participate actively in the energy market and in demand response schemes such as smart metering programs, light controllers, PLCs,[27] SCADA systems,[28] weather station or a platform

[27]PLC is a digital computer used as control of machines, in many industries and designed for multiple arrangements of digital and analog inputs and outputs, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact.

[28]SCADA (Supervisory Control and Data Acquisition) is a system for remote monitoring and control that operates with coded signals over communication channels (using typically one communication channel per remote station).

incorporating an optimisation-based Building Energy Management System for improving the energy efficiency, for example, in residential microgrids.

- The application for use cases will vary from, for example
  - in terms of energy generation, storage (e.g. batteries, fly wheel, etc.), and loads as well as the strategies of operation, addressing both thermal and electrical energy management
  - concerning thermal inertia of buildings and building services such as water boilers or heat pumps, as well as home appliances (while taking into account their comfort and preferences), or
  - technological developments for hydrogen production and storage addressed in the frame of the Fuel Cell and Hydrogen JU.
- Demonstration and validation of new business models for a combination of distributed energy resources, self-consumption and storage with optimised utilisation of distribution networks from all energy carriers (cf. Fig. 13.1).

13.3 Soft Engineering—Towards Connected City

The user involvement in many areas is and has been a self-clear phenomenon, especially in service sector or in architecture, interior design, clothing. For example, functionalism has targeted to help building occupants to work effectively and dwell comfortable with spaces and furniture for easy household and housekeeping. But experts decided or studied what is best for people in labs with relatively limited samples. Just in the dawn of intelligent buildings was realized for example that all in reach of hand within the office desk might not be the healthiest and thus the most effective way of working. Currently, studies on true usage environment with large number of users is acceptable.

13.3.1 Intelligent Building Concept—Organizational Approach

The European Intelligent Building Group has had a good start for applying the organisational approach to the concept of intelligent building.

Emeritus Professor Derek Clements-Croome started the provision of a Master course on intelligent buildings at the Reading University. Their resent definition for intelligent building is activation-based and comprises the user involvement:

> *'An intelligent building is a dynamic and responsive architecture that provides every occupant with productive, cost effective and environmentally approved conditions through a continuous interaction among its four basic elements: places (fabrics; structure; facilities): process (automation; control; systems): people (services; users) and management (design; construction; performance) and the inter-relationship between them.'*

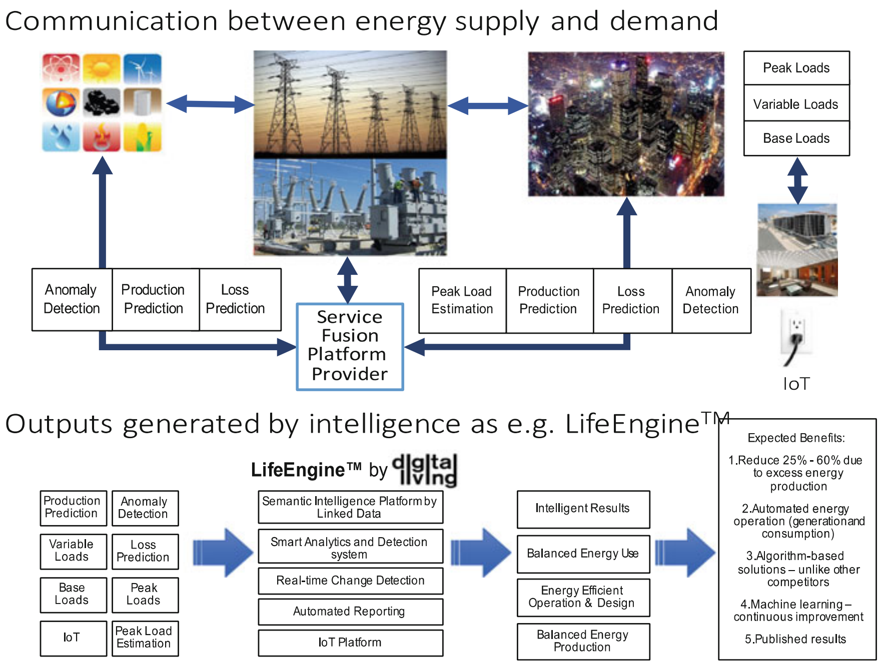

Fig. 13.1 Expected benefits of the Smart Grid by an example of semantic intelligence and linked data platform (LifeEngine) drafted by Ass. Prof. Oswald Chong [18] at Arizona State University

13.3.2 Buildings have Senses

In addition to the technological, organisational and activity-based definitions there are intelligent building definitions which approach the metaphor between man and machine. In science (source unknown) have popped up the idea that we build environment and related technology or artefacts that are alike human, similar to us or resembles ourselves. Also the metaphor between human and building or technology can be found; understanding how we copy ourselves—senses and cognition—into artefacts. The Swedish company T.A.C who later was merged with Schneider Electric introduced the concept of smart building as a metaphor between human senses and building automation. Automation components corresponding the human senses when placing on a level the human senses integrated into a person and the integration of building systems into the building (Himanen [45] p. 59).

T.A.C. together with NCC, a construction company from Sweden, was the key player of the EU FP6 project EBOB Energy Efficient Behaviour in Office Buildings (EBOB [29]). The combination of the human and social perspective with advanced modern control and ICT solutions called ‘forgiving technology’ was in focus (the concept initiated by the representatives from NCC Sweden and T.A.C., Himanen et al. [48]). The concept was targeted by the use case of making energy efficient behaviour natural, easy and intuitively understandable for the end-users, and at the same time to achieve the most energy efficient solutions while improving standards on indoor comfort in refurbished and new office buildings. Subjects on energy efficient end-user behaviour are still topical in the EU H2020 research for Energy Efficiency.

13.3.3 Buildings Borrow Cognition

The first intuitive expert guess of the author for the definition of the intelligent building concept was based on the idea of human intelligence in personal mental growth of the occupant as 'Intelligent Buildings are to be built after the needs of a person growing wise' (Lehto et al. [57]).

The building intelligence was then approached from two angles of cognition, First, search after the properties of building intelligence by a field study in real use environment with a sample of 12 buildings of which a half was intelligent and other advanced high class office buildings. Second, placing on a level the forms of human intelligence defined by Howard Gardner [42] and the hypothesis of the forms of building intelligence following the human approach (Fig. 13.2). The empirical sub-studies enabled to conclude that the designers had embedded human intelligence into technology in the forms of: ambient, dynamic, logic, connectivity and self-recognition. The classification was found from the seven forms of human intelligence defined by Gardner [42]: logical mathematical, linguistic, musical, visual-spatial, bodily kinesthetic, interpersonal and intra-personal.

The author's definition differs from others remarkably as other features (properties) than logic has been included in the concept of building intelligence: the spatial (ambient)—kinesthetic for adaptations (dynamic)—building knows its condition (self-recognition)—building informs of its status (connectivity). This type of holistic view could be worth of thinking for example in personalised computing or in role, event- and content-based applications.

The Intelligent Technology Framework describes the knowledge transformation process from design into usage of building and the role of the end-user involvement

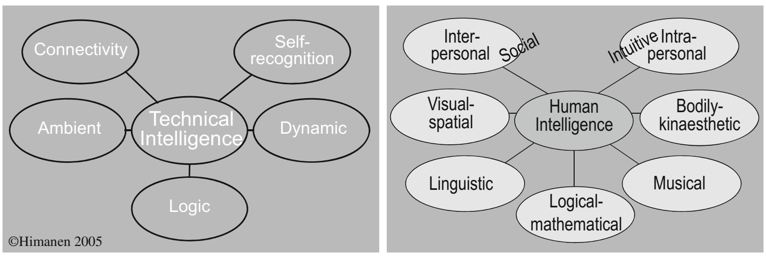

Fig. 13.2 The forms of building intelligence [45]

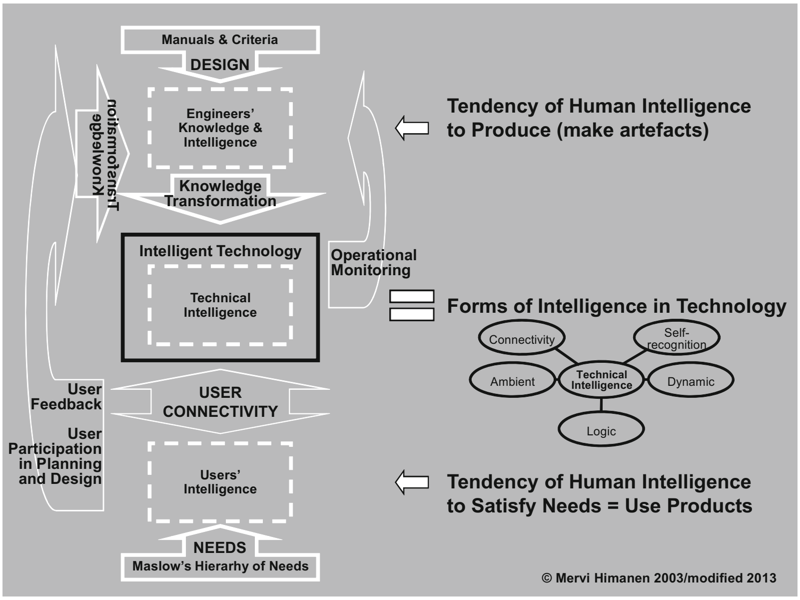

Fig. 13.3 The intelligent technology framework [45]

in it (Fig. 13.3) which at time being was not at necessarily clearly visible (cf. explicit) in design or soon that after. The learning cycle of Nonaka and Takeuchi [69], in Tuomi [87], p. 323) was used to understand the various forms of knowledge transformation and explain the process especially the tacit knowledge role in design (cf. implementation of the Nonaka and Takeuchi learning cycle in development of apps in Himanen et al. [47]).

The author has yielded from inductive reasoning after her empirical research on Intelligence of Intelligent Buildings (2003) that

- tacit knowledge of the designers which in general is difficult to comprehend consciously in the form of explicit knowledge is manifested in user feedback of the design and
- the influence of tacit knowledge on the buildings can be tracked by studying the explicit outcome—the intelligent building itself—with the end-user feedback of it (cf. Section on Total Building Performance and Buildings have Senses). This concerns any type of design.

In implementation of intelligent systems there are several layers starting from the physical layer of the real world items. Information is transferred from real world to the smart systems and for smart operation to follow. These layers are turning to cloud as platforms. On the top, there is the knowledge layer or cognitive layer, it is a platform where the algorithms of artificial intelligence and semantics operates by analytics or linked data technology for linking data, information or knowledge in order to enable operations is need. Actually, smart technology is a set of knowledge management tasks, mainly for decision-making, design and digitalization. The more sophisticated technology the better user involvement possibilities the algorithms in intelligence of technology allow.

The concept of intelligent building can be understood as a process of the knowledge management. When the engineers design and plan, they transfer their intelligence to the building. As well anyone can transfer ones intelligence to any artefact e.g. in the fields of manufacturing and service provision. It is clear that the previously learned knowledge in design tradition which is in explicit form (in calculation rules, guidebooks, regulations, etc.) will be copied to the new plans. The multidisciplinary user studies showed that intelligent technology is an outcome of the combination of explicit knowledge and thinking of engineers representing tacit knowledge which has not necessarily clearly manifested in physical form but the users can sense it. In other words, tacit knowledge can be defined by studying the result of engineering.

This type of thinking has value for example when describing how the process of design takes place and what is included into the design from the end-user feedback and from the tacit knowledge of the designers before it becomes in written form in the design guidelines (cf. PAS Standards Section Standardization of User-driven Smart Environment).

13.3.4 User Involvement in Smart Innovation

Always building and technology has aimed to help people to lied good life. The basic requirements to build a shelter for humans, from dangers such as climate and weather or animals and hostile intercourse, are understood as self-clear in a modern society.

Already industrialism and currently, information or knowledge society has increased the requirements of highly qualitative built environment while availability of resources or affordability does not dominate the demand in market. People like to increase their quality of life and accordingly the quality of built environment, the venue for living, pleasure or working. Workplaces have turned to a factors of effective production from being a costly burden of the production. A productive and cost-effective built environment was gained through optimisation of architecture, structures, building services and management, and the interrelationship between them.

The freedom of choice in accordance of one's own preferences is large in the case of owner-occupied private houses which the owner has had built her or himself. Motivation on developing user involvement further comes from

- Unsatisfied needs of the residents and other occupants and tied to the local real estate broker's offering or what is listed in the manufacturer's catalogue.
- Tenants' possibilities to influence one's housing conditions are limited.

- Home buyers have few opportunities for influencing their future homes. People have different ways of living but constructors are still largely stick to the concept of a family unit with two parents and two children. Individual and local needs are pushed toward while all families do not fall within this category.
- Occupant in public or commercial buildings has limited possibilities to influence the design of their workplaces which the company representatives or executives often select. They are seldom involved in the initial stages of building such as in user requirement definition, commenting design drafting phase.
- It is claimed that the building developers and contractors as well as the institutional building owners—are not particularly interested in offering many alternatives.
- Designers are afraid of failures when experimenting new solutions which is both costly and spoils one's reputation.

A key issue still left was how to organise the interplay between user and machine or the machine to customer relationship (M2C) so that one can

- avoid machine controlling over human as we like to be aware of the actions going on in house but interfere as little as possible to the automated tasks when the manual mode is not preferred,
- deal with complex problems while human brain is able to operate with 7 issues at time in average (LeDoux [54] pp. 271).

The user involvement in design or operation of smart built environment has a new mental thinking pattern with advanced driving forces. They are (1) competiveness of various concepts and brands, (2) ecological sustainability, and (3) social impact of new building innovations or applications in facilities management and housing related e-services. Especially, serving certain user groups with solutions for their needs has popped up, as for example in housing among elderly and singles who are interested in housing concepts where they can choose between their own privacy and the common spaces, because loneliness is one of their major problems. In offices the way of working dominates the needs of space. In industrial practice, the building managers' possibilities to influence the decision-making of spatial arrangement have been experienced low. The management of core processes of the business dominates over the most effective way of building management. It is not a common practice that the building manager is the member of the board directors.

Taking end-users into account is not always easy (as reported for example by Ms Sonja Frosti at Digital Living Finland Ltd in Himanen et al. [47]) or considered not to be necessary (van Berlo [11, Toivanen 85]).

The user interest dominates the commercial demand. Recently, we have learned to admire firms that experiment and pilot with customers for new service and business models or user-driven innovation (von Hippel [49]), and create open source and social network-based innovation. Von Hippel argues for 'consumer innovations'; traditional division of labour between firms as innovators and customers is breaking down; a large portion of innovations comes from markets and customers.

Companies such as AGC, IBM, Nokia and many others have used new tools on social media or, end-user-oriented market study methods to increase their sales even with millions of customers. Such methods have been popular as, e.g. crowd-sourcing,[29] living labs born in Massachusetts Institute of Technology (MIT) (cf. Tang et al. [82] and [83], ENoLL, the European Network of Living Labs (www.openlivinglabs.eu)) or caving[30]. They provide dialogue for identifying the strategic challenges and grounds for their innovations. Still, the traditional methods of interviewing work well too, in this new context.

Short user studies by questionnaires have been a norm in property and facilities management companies to gather end-user feedback. Those questionnaires have moved into Internet. Internet and social media make a powerful platform for co-design. On the other hand, some building managers have even argued that listening without following corrective actions is enough.

User involvement may reach towards the role of a developer. Informing of one's needs might be relatively passive while just answering the questionnaire or to interviewer's questions. Neither the questions nor the analysis does necessarily head to figure out the problem of the user that the product or service should solve. The focus easily remains limited to the properties of the current product or service, and slight changes to be made.

The Finnish Government's innovation strategy [10] highlights skilled people and close-knit innovation communities as crucial for the competitive edge in the world economy (Fig. 13.4). Innovations are most often the fruit of new combinations of competencies crossing industry and disciplinary boundaries.

Nonaka and Takeuchi [68] argue for distributed leadership where wisdom is embedded in every individual and collective practice and action. They discuss cases of major structural, social, institutional and economic transformation where citizens, public agencies and firms have together saved their cities or lakes in crisis and brought them back to prosperous economic and social progress and development path for future. The distributed leadership includes competence of grasping the essence of a problem and knowing how to draw conclusions and acting on them immediately. This is 'hands-on' leadership in touch with the reality. This also implies that we consciously act based on values such as goodness, beauty and truth; they are applied, tested and recreated together with other people in every action.

There has always been self made men and volunteering among village men for building homes. The future studies identify the trend of individualism which has been one of the drivers for new forms of user-driven building. Individualism

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[29]The practice of obtaining needed services, ideas or content by soliciting contributions from a large group of people and especially from the online community rather than from traditional employees or suppliers.

[30]A form of virtual reality is Caving. Cave is a room where its walls are typically made up of projection screens, where a computer-generated world is projected on the walls. In this a virtual reality where the user can experience the design before realization.

Fig. 13.4 Basic choices and key development areas for the innovation strategy 'A national innovation strategy' [10]

involving men and women which is important to remember because gendered innovation has been recognized both as a lacking in current production and thus one of the key success factors (Expert group "Innovation through Gender" et al [39]).

In Finland, the new forms of primary end-user involvement in smart innovation are such as a modern town houses with low ecological footprint, cohousing, group housing. The townhouses have the properties of raw houses without a garden. The Finnish group housing stands rather for self-acting homebuilding than putting emphasis on shared space and facilitation for communal dwelling. The members of the group housing group share the expert knowledge and facilitation for building during the building process as well as the costs due these activities. That after they can be rather independent unless they have not wanted to share any buildings with their neighbours. Both concepts have also legal status.

Internationally cohousing is understood as a type of intentional community composed of private homes supplemented by common spaces and shared facilities (cf. Vestbro [89], CoHousing Cultures Handbook 2012). CoHousing Platform (on http://co-housing-cultures.net/) summarises such keywords of cohousing as self-organised, community-oriented and sustainable, integrating, non-speculative and open to the neighbourhood, affordable and socially designed homes. The community is planned, owned and managed by the residents—who also share activities which may include cooking, dining, child care, gardening, and governance of the community. Common facilities may include a kitchen, dining room, laundry, child care facilities, offices, Internet access, guest rooms and recreational features.

According to the Houser Study (Himanen and Korhonen, [46]), the modern scheme of resident-driven housing business is in an early dawning phase in Finland based on the very low numbers of operators (about 150 in 2012) and their minimal share of the total housing construction volume. Into the sample was included companies who were involved in planning or complementation of such new user-driven housing concepts as cohousing, group housing, house builders as self-made men, plumbing renovation, independent living. Using the rough estimation of 6,000,000 M€ as the turnover of housing construction in 2011, it can be concluded that the resident-driven housing business corresponds less than 0.4 ‰ of the total of housing construction. This innovative niche in housing business is dominated by recently established micro and small companies. However, already also some of the big companies (10 of them in the sample) take part in the business by developing further their well established business concepts that might have been established a few decades ago.

13.3.5 User-Oriented Intelligent Building

Among the first ones to introduce the end-user approach to office design were the Skidmore, Owens and Merrill Architects in the 1980s in USA (www.som.com). Large post-occupancy studies followed the creation of intelligent building concepts and the realisation of smart buildings: e.g. (1) the ORBIT studies carried out by the Harbinger Group of Connecticut (Davis et al. [22], Duffy [27]), (2) the Intelligent Building in Europe [9] and the Office Tenant Survey of the BOMA and the (3) ULI [8]. They examined current practice by the user feedback, user requirements and changing work patterns in relation to the productivity of the work environment.

These studies focused on interior design and its meaning to the working performance. Factors of impact on environmental quality comprise colours, adaptation of spaces or furniture, active structures as automated walls and doors, etc. As well, leading engineering and architects' offices, which are many, have developed their design office layout further from these principles to have knowledge work places. Further on, the idea to stimulate the human brains which is the only 'raw material' of knowledge work is originated from the very first intelligent offices. Odours, music, water elements, etc. were used.

The Danish Professor Fanger started the indoor quality studies; conducting field studies on various parameters of the air quality as well as studies in laboratory conditions on the interplay between the air quality and user's work performance. Currently, the studies following Fanger's footsteps comprise an integrated concept of indoor environment quality, which is a part of the Total Building Performance concept.

The statistical significance in results was found in favour of intelligent buildings within the field study with a sample of 12 buildings which compared intelligent and other high class office buildings in true use environment of 534 office workers and a large number of parameters both in questionnaire survey and measurements of the knowledge work environment (Himanen [45]). The survey had drawn much from the above-mentioned large post-occupancy studies as well as from the indoor air quality studies. In addition, such other factors as influence of clothing or travelling were in. The new buildings were at same age and located in Helsinki Metropolitan area. The main criterion was the end-user feedback of the work spaces and the performance of office and building automation and their meaning to the end-users' work efficiency and efficiency.

Today, for example, studies carried out by Social Networks Analysis cover wide range of parameters with wide stocks of data, i.e. big data (cf. IEN Innovation Ecosystem Network, www.innovation-ecosystems.org). The scope of studies on intelligent built environment has expanded into studies on the smart city phenomenon. The partners involved in research and innovation come from all walks of life not only from scientific disciplines (cf. S3 Smart Specialisation Platform, a research scheme conducted by quadruple helix comprising academia, industry, public sector and end-users).

In her study on electronic services in municipalities Toivanen [85] found the large influence of attitudes and leadership style of developers and providers when applying ICT into service provision. Toivanen [86] emphasized the meaning of providers' positive and warm hearted attitudes towards end-users. She identified the meaning of predictability in defining even unconscious needs and desires of the end-users. When co-creating new services the interaction need be cordial and warm between end-users and service provider and the delivery. A new product or service must the answer to the true needs and expectations of the end-user and not the ones the provider has extrapolated (cf. Himanen et al. [47] on more about Toivanen's and others' research on user-driven innovation).

A strong emphasis on the development of the end-user involved smart environment has been and is within the AAL Joint Programme for funding research and innovation on smart housing, independent living and well-being of elderly and their communities (family, caregivers, neighbourhood, service providers, care system, etc.). The innovations should include both a user-centred approach and pilots with a considerable number of end-users involved in order to demonstrate the benefits and added value necessary to make impact on the market.

The definition of end-users in the AAL Programme

1. Primary end-user is the person who actually is using an AAL product or service, a single individual, 'the well-being person'. This group directly benefits from AAL by increased quality of life;
2. Secondary end-users are persons or organizations directly being in contact with a primary end-user, such as formal and informal care persons, family members, friends, neighbours, care organizations and their representatives. This group benefits from AAL directly when using AAL products and services (at a primary end-user's home or remote) and indirectly when the care needs of primary end-users are reduced;
3. Tertiary end-users are such institutions and private or public organizations that are not directly in contact with AAL products and services, but who somehow contribute in organizing, paying or enabling them. This group includes the public sector service organizers, social security systems, insurance companies.

Common to these is that their benefit from AAL comes from increased efficiency and effectiveness which result in saving expenses or by not having to increase expenses in the mid- and long term.

This user classification could be modified to be used in other context as well.

Digitalization enables building of digital ecosystems where the entire information process of service provision or production will be renewed. It concerns raw material, data sources, organization, process schemes, etc. and their place in the system or consideration of their existence or disappearance.

13.3.6 Standardization of User-Driven Smart Environment

Instead of smart building standards next will be referred the end-user related building standards and smart city standards.

The ISO (International Organization for Standardization) and the CEN (European Committee for Standardization), as well as, the Cenelec (European Committee for Electrotechnical Standardization) have launched standards related to user involvement and some of them are specific for building sector:

- ISO 21542:2011: 'Building construction—Accessibility and usability of the built environment'
- CEN/TS 16118: 'Sheltered housing (Requirements for services for older people provided in a sheltered housing scheme').

Human-centred design overall has established practice defined by

- ISO 13407 new version of ISO 9241-210: 'Human-centred design for interactive systems',
- ISO 13407:1999 Human centred design processes for interactive systems,
- ISO/TR 16982:2002: 'Ergonomics of humansystem interaction—Usability methods supporting human-centred design'

The interplay between human and robots can benefit from:

- ISO 8373: 2012. Robots and robotic devices—Vocabulary. International Organization for Standardization, 2012. 38 p.

For time being, technology standards are just in infancy at smart application level such as OneM2 M (ETSI partnership) in the Smart Mobility area and possibly soon some W3C initiatives the European M/490 Smart Grid mandate (ETSI/CEN/Cenelec) in the smart energy domain and possibly soon some W3C initiatives. A much stronger effort should be dedicated in this area in the future.

The Publicly Available Specification (PAS) is a sponsored fast track standard driven by the needs of the client organizations and developed according to guidelines set out by British Standards Institution (BSI). The PASs are intended for city authorities and planners, buyers of smart city services and solutions, as well as product and service providers such as national and local government departments, utilities, healthcare providers, transport, construction companies, ICT solution providers, city planners and developers. Some of them are particularly relevant to national and local government departments, utility companies, healthcare providers, transport service providers, construction companies, network companies, city planners and developers, designers, and vendors of ICT solutions be they big players, SMEs, or their clients.

The PAS defines a smart city as one where there is 'effective integration of physical, digital and human systems in the built environment to deliver a sustainable, prosperous and inclusive future for its citizens' [71]. The Executive summary of the PAS Standard on 'Smart city framework—Guide to establishing strategies for smart cities and communities' defines the concept of smart city in detail (Fig. 13.5, [72]).

The relevant titles for this review in the PAS Smart Cities suite include

- PAS 180:2014, Smart cities—Vocabulary, which defines terms for smart cities, including smart cities concepts across different infrastructure categories. To help build a strong foundation for future standardization and good practices PAS 180 provides industry-agreed understanding of smart city terms and definitions to be used in the UK for providing a common language of smart cities for developers, designers, manufacturers and clients.
- PAS 181:2014, Smart city framework—Guide to establishing strategies for smart cities and communities, which gives guidance on a good practice framework for decision-makers in smart cities and communities (from the public, private) to develop, agree and deliver smart city strategies that can transform their cities' ability to meet future challenges and deliver future aspirations.

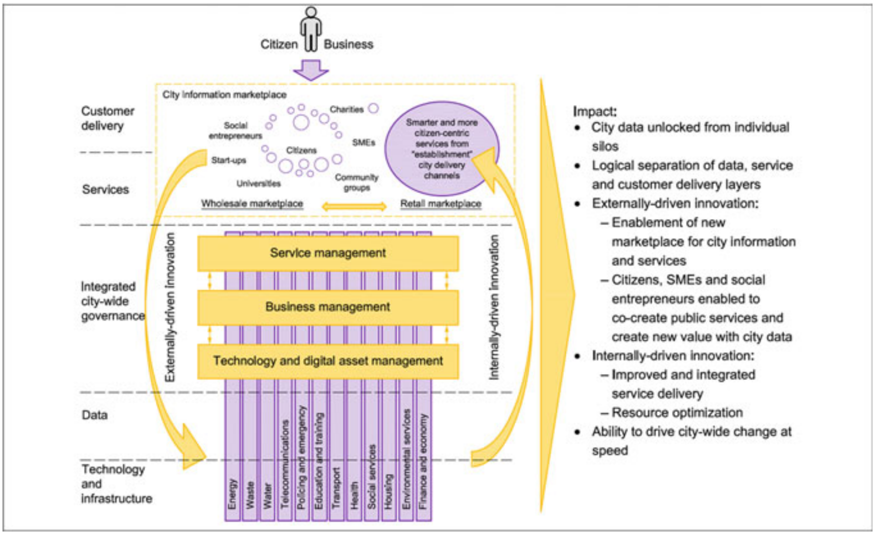

Fig. 13.5 New integrated operating model: in transforming cities to smart cities (PAS 181 [72])

- PD 8101:2014, Smart cities—Guide to the role of the planning and development process, which gives guidance on how the planning and implementation of development and infrastructure projects can equip cities to benefit from the potential of smart technologies and approaches (© The British Standards Institution 2014 and voluntary sectors). The guide is relevant to major developments, infrastructure projects, refurbishment programmes and improvements to public spaces. It considers how each stage of the planning and development process could support smart city opportunities and sets out what needs to be done at each stage.
- PD 8100:2014, an overview document that will provide guidance on how to effectively communicate the value of smart cities to key decision-makers. It gives guidance on how to adopt and implement smart city products and services in order to facilitate the rapid development of an effective smart city. It describes in detail the potential benefit of smart city strategies, provides recommendations on how to identify the first steps towards making the city smarter and covers the role of technology and data in providing the tools in this process.
- PAS 182:2014, Smart city concept model—Guide to establishing a model for data interoperability, which provides a framework that can normalize and classify information from many sources so that data sets can be discovered and combined to gain a better picture of the needs and behaviours of a city's citizens (residents and businesses). It gives guidance on how to promote data sharing across sectors in a city and help bridge the differences in data analysis between sectors like health, education and transport. It is intended to facilitate discussions between decision-makers and the specialists who build and design the systems and services that enable a city to function. The guidance addresses the fact that service providers do not always have the expertise to analyze the data they accumulate, that different sectors use a different language when describing data and offers a model that can be used by a variety of sectors.

In the context of smart city, the BSI refers also standards for

- Quality of life and services in cities: BS ISO 37120:2014 Sustainable development of communities. Indicators for city services and quality of life.
- Research on smart infrastructure projects: PD ISO/TR 37150:2014 Smart community infrastructures. Review of existing activities relevant to metrics.
- A specification for KPIs for smart infrastructure projects: PD ISO/TS 37151:2015 Smart community infrastructures. Principles and requirements for performance metrics.

13.4 Future Potentiality

Keywords of opportunities for construction in smart built environment can be listed: Apps for building on smart phones—Artificial Intelligence—Augmented Reality—Building Automation on Cloud and SaaS—Big Data BIM—Caving—

Clouding—Digitalization—Drones for scanning[31]—3D Printing—robotics—Telepresence[32] or Holoportation[33]—Integrated FM—Horizontal Platform—Internet of Things—Machine Guidance—Open data—Virtual Reality.

13.4.1 BIM—Building Information Management

The need to extend computer aided building design to construction and to real estate management phases of building has been on agenda from the very beginning of the born of smart building concept but still not reality today in mainstream building.

Nordic countries are often cited amongst the five strongest regions in the world regarding BIM implementation. Developments have taken place due to an awareness of the great potential for enhanced efficiency and productivity, not as a result of the demands of public construction client organisations, which have been the main driving forces in Norway and Finland. In Finland already in 2007 Senate Properties required information delivery of public building design in the form of BIM and prepared a BIM manual for documentation of new construction development (www.senaatti.fi/en). The shift from drawing-based design into the information-based one occurred. Instead of CAD drawings (Computer Aided Design)—which are familiar with all design software providers—the public real property developers started to require object-oriented databases to be carried out by BIM-based software on IFC standard (Industry Foundation Classes developed by the International Alliance for Interoperability (IAI)).

Just recently, BIM can be defined both as a technology and as a method applied to create, communicate and analyze building information models. The UK and Sweden are used as examples of this progress recently done in the UK and intended in Sweden.

In the UK, a national BIM strategy for the building sector has been initiated, in which the government, the private sector, the public sector, research institutes and academia are collaborating. The general aim of the strategy is to simplify and

[31]Drones are more formally known as unmanned aerial vehicles (UAV). Essentially, a drone is a flying robot. The aircraft may be remotely controlled or can fly autonomously through software-controlled flight plans in their embedded systems working in conjunction with GPS. UAVs have most often been associated with the military but they are also used for search and rescue, surveillance, traffic monitoring, weather monitoring and firefighting, among other things.

[32]As a form of virtual reality, telepresence is term used for a set of interactive technologies such as high definition video or audio that permit the users to feel or appear as if they are present (and able to influence and operate) in a location in which they presently are not physically not located.

[33]The HoloLens, Microsoft's much-hyped new augmented reality (AR) headset—a solution of telepresence. A series of cameras are set up around a room, tracking shapes and movement and stitching a 3D model together in real time. Speaking and interacting with remote friends, family, and work colleagues could become almost as natural as it is when you are face-to-face—except for the fact that everyone involved has to have a heavy AR device strapped to their head.

expedite BIM adoption throughout the sector and establish uniform requirements for BIM implementation in government-funded projects. Effective information management leads to business efficiency and profitability. Without the standardized approach to authoring of both geometrical and non-geometrical objects, any outputs from the model will be inconsistent and will not return valid results for schedules and other information-related queries. Following the Government Construction Strategy in 2011, the UK Government required fully collaborative 3D BIM (with all project and asset information, documentation and data being electronic) as a minimum by 2016 (NBS [64]). In 2015 NBS could conclude that they have clearly moved on from the time when 3D CAD could be mistaken for BIM:

> '*At NBS we have been working to deliver increasingly sophisticated, and standardized, levels of information into the federated information model through the timeline. This began with our innovative specification product, NBS Create, and then developed through the creation and growth of the NBS National BIM Library. We were able to fully integrate these products together through plug-ins, allowing information to be co-ordinated between the specification model and the geometry model. 2015 sees the next stage in this trajectory of development. Part funded by Innovate UK, and produced in partnership with the industry, we have released the NBS BIM Toolkit. This free to use toolkit offers a digital Plan of Work tool, and a new unified classification system. It provides support to define, manage and validate responsibility for information development, as well as its delivery, at each and every stage of the construction life-cycle.*'

Since 2015, in UK the standardization of BIM comprises such standards as (NBS [65])

- PAS 1192-5 Security,
- PAS 1192-3:2014 Information exchange—COBie—BS 1192-4:2014,
- PAS 1192-2:2013 Information management process,
- PAS 91:2013 Construction pre-qualification questionnaires,
- BS 8541 series Library objects for architecture, engineering and construction,
- BS 8536:2015 Facilities management briefing for design and construction,
- BS 7000-4:2013 Design Management Systems,
- BS 11000: Part 1 2010 and Part 2 2011 Collaborative Business Relationships, and
- Guide to managing design in construction.

Hamil (in NBS [64]) concluded that in the UK, the foundations for a digital construction future are now being put in place. These foundations include consistency in classification, standardized information requirements and guidance to help make the correct decisions quickly. In addition,the move to the cloud is changing the way teams collaborate through data access anddata sharing. With this in place, what will the construction industry look like in 2020?

In Sweden, Andersson et al. [4] summarize that BIM involves analysis of factors such as material strength, power consumption, noise, indoor air quality, constructability, occupational health and safety, accessibility, architectural design, cost, time and resource planning, supply chain management, operational optimisation and use of space. In other words, it concerns all the information that will be used at different stages in a facility's life cycle. Above all it involves simulating and optimising many of these factors from a long-term perspective. BIM entails the utilisation of information in a systematic manner being consistent with three-dimensional designs and explicit classification of information concerning the facilities. Thereby BIM facilitates all the possibilities that the technology provides in relation. BIM applications are usually divided into three main stages; (1) Three-dimensional models for visualisation and interaction; (2) Integrated analysis; (3) Automation linked to industrial processes.

By industrial processes Andersson et al. [4] mean that the processes are standardized and that platforms, products and information support are disconnected from construction projects and property management, and are developed independently from a life cycle, sustainability and customer perspective, then applied during construction and facility management. The recurring activities of construction and facility management are standardized, and the best overall solutions, such as inputs, subsystems and complete modules, are developed as separate platforms. Platforms and products are then offered in specific market niches.

The US and Singapore are other leading countries in usage of BIM.

13.4.2 3D Printing

In addition to new digital capabilities, 3D printing (cf. Additive Manufacturing (AM)[34]) allows the localisation of production, easy design modification and customisation as well as the introduction of technical, user centred (pls read: personalized consumer ready products) and aesthetic capabilities that are new to traditional industrial terrain.

As the organic architecture,[35] 3D printing can totally change the thinking of building. It is not any more fully clear for example where the wall transforms into roof while the printer structures a solid surfaces that serve multiple purposes as Prof. Arto Kiviniemi at Liverpool University has pointed out. The relations between objects in CAD and BIM tooling need radical redefinition.

By utilizing 3D printing in place of conventional construction techniques, the building's engineers project significant savings in time and costs, with estimated 50–70 % reduced production times, 50–80 % reduced labour costs and 30–60 %

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[34]Additive Manufacturing refers to a process by which digital 3D design data is used to build up a component layer by layer using materials which are available in fine powder form. The term of professional production technique '3D printing' is increasingly used as a synonym for Additive Manufacturing. The technology has especially been applied in conjunction with Rapid Prototyping and now being used increasingly in Series Production.

[35]Organic architecture is a line of architecture which promotes harmony between human habitation and the natural world. This is achieved through design approaches well integrated with a site that buildings, furnishings, and surroundings become part of a unified, interrelated composition. Architect Frank Lloyd Wright used to describe his approach to architectural design by this concept.

reduced construction waste (Nield [67]). One of the biggest potential impacts of 3D printing technology is expected to be in creating low-cost and environmentally friendly housing. The world's biggest 3D printer can make houses out of mud, clay, water, dirt, and natural fibres, avoiding the expense and environmental consequences of cement.

Authorities in Singapore have announced plans to provide residents with 3D printed houses, and are now conducting a feasibility study to figure out how to get it Done, Nield reports [67]. If the proposal gets the go-ahead, house storeys will be printed independently and then assembled on site in the style of Lego bricks. When it comes to the Singapore project, not every part of the house would be 3D printed but just the main structural components. Any elements that cannot be printed cost-effectively could still be put together using traditional methods. The aim is to use machinery to build homes for Singapore's elderly population without relying on foreign labour, although the printing technology for concrete elements which is at the centre of the scheme is still in the development phase.

The UAE National Innovation Committee has proposed for construction a temporary headquarters for the facility's staff of Museum of the Future as the world's first 3D-printed office building in Dubai, Dockrill reports on ScienceAlert.com [25]. It will occupy close to 200 square metres of land. The completion date of the project has not yet been announced. It is set to be printed by a 3D printer measuring some 6.1 m tall, with the individual components subsequently assembled on site 'in a matter of weeks'.

13.4.3 Open Data—towards Collaborative Economy

With Open Data is meant the opening of information resources free of charge, in machine-readable format and with transparent conditions of use to businesses, citizens and society as a whole by the end of the decade. The goal is to create favourable conditions for new business activity and innovations, strengthen democracy and civil society, enhance administration in general and digitalization of it, and diversify the information resources available to education and research. The objective of Open Data initiatives includes on one hand, new business ideas with the aid of open data and better utilization of information resources, and on the other, the rationalisation of existing practices. The Government Programme also seeks to strengthen knowledge-based decision-making and openness.

The concept of collaborative economy is also used. It is defined as initiatives based on horizontal networks and participation of a community. It is built on 'distributed power and trust within communities as opposed to centralized institutions', blurring the lines between producer and consumer (Botsman and Rogers [13]). Transactions are facilitated via community-based online services. Also the term of shareconomy is used referring to a hybrid market model (in between owning and gift giving) of peer-to-peer exchange.

The EU's PSI (Public Sector Information) Directive on the reuse of public information resources aims to common practices and structures standardizing and to support the systematic opening of information resources. It is recommended that the standard open and internationally interoperable licence Creative Commons Attribution 4.0 (CC BY 4.0) be adopted in the reuse of the public sector's open information resources. A number of public authorities have adopted the recommended licence.

The second step of this open government process is to offer Open API to developers. Here it is possible to retrieve data but also to send some information or request. Open API are documented web services that allow programmers to interface directly with cities IT infrastructure without going through a human (like when going through a hotline) or a fixed interface (like filling a form on a web site). The goal is to offer the opportunity for third parties to develop applications on the top of city platform and create new services at better price for the benefit of the citizens. Some cities have even already launched their own app store. These Open APIs unleash a wide range of new services that would never have been considered by the city itself by lack of budget, creativity, insight, etc. Most of the applications are targeting mobile platforms (thus benefit from these platforms sensors and features like geolocalisation) and need to be integrated in social networks.

The European Data Forum (EDF) is a meeting place to discuss the challenges of Open Big Data and the emerging Data Economy and to develop suitable action plans for addressing these challenges (www.europeandataportal.eu/en). The European Commission Vice President for the Digital Single Market Andrus Ansip has stressed the importance of data to 'be able to move freely, across national borders' and 'any unnecessary or unjustified barriers should be stopped'. The European Data Portal does that by harvesting the metadata of Public Sector Information available on public data portals across European countries. Information regarding the provision of data and the benefits of reusing data is also included. Going beyond the harvesting of metadata, the strategic objective of the European Data Portal is to improve accessibility and increase the value of Open Data.

Examples of international cooperation are participation in the EU's SharePSI project, which seeks to develop international best practices in open data, and the Nordic Open Data Week 29 May–7 June 2015.

For example, according to the Finnish Open Data Programme 2013–2015, set up by the Ministry of Finance, open data will become a regular part of administrative activity. It has been prepared as part of the planning of the central government spending limits and as part of the general government fiscal plan. Every year, the Ministry of Finance has requested from the ministries plans outlining which information resources will be opened in the administrative branches and what the economic and social impacts will be. A growing number of municipalities are also opening their data while in Finland the central government and local government data are under separate authority: Ministry of Finance and the Association of Finnish Local and Regional Authorities.

Opendata.fi, an open data and interoperability service, was launched in 2014. The service aims to provide information about opened data resources as well as interoperability descriptions and guidelines for centralised use. Currently (2016), the service offers information diversely, on more than 1,400 opened resources, comprising the material from terrain data to weather, climate, sea, transport, financial, statistical and cultural data, the legal databank Finlex, owned by the Finnish Ministry of Justice, etc.

13.4.4 National Architecture for Digital Services

We are heading the era of digital economy and economy of platforms. Artificial intelligence and semantic web technology are realised to solve the problem of siloed systems which have dominated, e.g. the social service provision or private service sector, industrial digitalization, etc. As mentioned, cities actively look after solutions for city platforms that comprise integration and interoperability of social services for all, public transport, energy efficient building, efficient city administration.

The solution to siloed systems, however, is not only technological while the organisational and economic obstacles dominate the decision-making on the usage of the technological potential. The interests collide. In this context, technology alone is discussed.

A firm basis for developing nationwide governmental or municipal e-services for all citizens is aimed by the National Architecture for Digital Services as targeted and pioneered in Estonia, Finland or Denmark, for example. The National Architecture for Digital Services will be a compatible infrastructure facilitating information transfer between organizations and services. It carries potential for increasing the use of technology for all citizens' welfare being compatible, and personalized as well as event or content-based.

Architecture of for national technology is aimed to be personalized and user friendly, as well as, simultaneously relatively cost-effective and sophisticated which is enabled by the currently mature enough technological readiness level due to the previous software development. Still, the greatest benefits also in economic terms will be yielded by the benefits after the implementation the technology. For example, in Finland by electric public services is targeted [61]

- To simplify and facilitate transactions by citizens, companies and organizations with the authorities and to improve security,
- To promote openness in public administration and to improve the quality of public services
- To enable cost-efficiency in online services,
- To improve shared use of information and the compatibility of information systems,
- To promote corporate opportunities for leveraging public administration databases and services,

- To support the national economy by making public administration more efficient and by creating new business opportunities in the private sector.

Today, one cannot deny that the National Architecture for Digital Services in Finland for example is not yet completely planned (cf. Frosti [41], Harald et al. [43])—not to mention implemented, while in addition to current plans, to employ the full potential of the national architecture, compatible inter-city service fusion platforms are needed or an Enterprise Service Bus (ESB) architecture, which take care of the systems integration and data interaction between the public and the city services.

The Data exchange layer of the Finnish National Architecture for Digital Services has been demonstrated in the context of the social and health care in the city of Espoo [6]. It turned out to be suitable for the social and health care service provision and to improve access to data and interoperability, but not yet complete. The data transfer requires similar quality criteria as the KanTa technology (National Archive of Health Information, www.kanta.fi/en). All the data have to be encrypted and digital signature need to be in use in order to guarantee a trusted operation.

There is currently no well-functioning government-wide data network in Denmark [52], but still Denmark is a good example of the governmental commitment on nationwide interoperability of all. 'Digitalisér.dk' is the central repository of information on data interchange standards for the public and private sectors and a collaboration tool for the development of information society in Denmark. Launched by the Danish Ministry of Science, Technology and Innovation in October 2008, as a successor to the Infostructurebase (ISB), it is a key strategic element in the country's eGovernment architecture. Its main purpose is to support the exchange and reuse of data related to public and private service delivery, including cooperation, business reengineering and alignment of related services. An important part of the content is the standards approved by the Danish e-Government IT architecture and XML committees.

'Digitalisér.dk' also provides an uncomplicated basis for debating common public digitisation by using intuitive web which will be based on interaction rather than formal processes.

13.4.5 Connected Society

Economic growth and globalisation increase in complexity, during the information age in particular. Knowledge society trusts on transparency making life less complex thanks to good data, information and knowledge management on cloud. Artificial intelligent engines help human mind to cope with living and work and decide on personal life or operation at work. Virtual reality helps to comprehend quick and easy. Qualitative knowledge becomes a key factor in economy, politics, in operational decision-making. Service chains become ever more smooth going and shorter in time due to dropping unnecessary phases, or material as paper, for example, becomes ever more virtual.

Prof. Mischa Dohler from Kings Collage trust on the promise of Big Data (2013; www.linkedin.com/in/mischadohler). CEO Pirkka Frosti from Digital Living International Ltd (www.digitalliving.fi) has since 2008 shared the same idea of taking advantage of Big Data in digital economy ending up virtual ecosystem building of real-world items on cloud, using a smart knowledge management engine for platform of linked data semantics. They both foresee that the hype on Big Data will be realised right after the data will be employed for the benefit of connected society. It needs applications easing daily activities, enabling decisions that are based on valid knowledge and working in role and content-based automated environments.

CTO Jan Byfors at NCC Construction Sverige AB concluded (2016) in his speech on 'Opportunities of the digitalization for construction' that '*Digitalization is the solution! Construction is lagging behind! … but catching up. The sector has already started its journey towards digitalization ….and that is BIM. BIM means Collaboration—a way of working. There will be new business logics. Sharing is the new norm. Digitalization is a game changer. Digitalisation is moving fast*'.

Byfors [16] urged the building sector: '*We have to adapt to the technology!*'

He foresees the IoT as a tool for realisation of smart homes, the implementation of the Integrated FM (facilities management) on the Horizontal Platform and Big Data. As well, IoT enables Smart City models linking real-world, land usage, levels, properties, roads and clients.

13.5 Discussion

Smart city and smart society carry a potential for advancing the beneficial and profitable use of smart technology. Among other things, the author's experience in adoption of information technology proves of advantages that will be achieved beyond the digital ecosystem. New technology has usually been implemented in the first place in certain parts of the entire operational ecosystem. Consequently, many advantages might be foreseen but only limited number of them can be directly realised. A wider digital ecosystem or business landscape is needed for indirect advantages to avoid the frustration of unfilled customer expectations or market promises (e.g. in interest of investors or funding bodies).

For example, an integrated home automation can save energy, but why invest in the all properties that smart housing technology provides, which might not be fully beneficial or, e.g. for safety can be purchased a mobile applications. The house automation and living can produce extra energy but before the smart metering and Smart Grid technology it cannot benefit the home owner. The unrealised vision of the integrated digital ecosystem from CAD and BIM via digitalized construction site management to smart integrated building automation and real estate property and facilities management has lived long in commercial building sector.

The requirement of integrated technology in the 1980s has turned out to be too high at that time, but the correct direction for the development was set. It has bear fruit and the readiness for smart housing, intelligent workplaces, smart cities, smart everything is good today. The best suited technology for applications in smart environment such as the linked data technology or semantic intelligence have just recently become promising enough to fulfil the requirements of integrating building technologies. But meanwhile, also new demand for integration or interoperability with smart city and Smart Grid concepts has risen. They are highly relevant and in need for better energy efficiency.

The original need of integration of technologies has been taken over by Internet which has reached all types of buildings and especially homes. Systems run after pre-decided algorithms on cloud. User operations are limited to pushing on or off. In homes entertainment and edutainment run on web by personal computers, smart phones and pads as well as via smart television. The same goes for example with safety and security applications. The original idea of integration in smart homes included the control of the home appliances, entertainment and energy supply and housekeeping facilitation. At time being, these systems run separately in the majority of homes but are going to be accessed on apps on smart phones, for example.

In the 1980s Intelligent Building Ass. defined the integration of technologies as the aim of the intelligent building research and development. This aim formed both the starting point and the driving force for the progress of the technology in concern. The implementation has followed accordingly and spread towards the concept of smart city. Due to the original aim in smart housing, the user requirements have not been paid special attention world wide which has hold up the creation of the smart services, especially those that are related to daily living and could interest the consumers or other primary end-user groups.

Nevertheless how highly in need in the dawn of digitalization the technology push approach has caused the lack of service-oriented approach in application development. The purpose of the technology has been lost. Technology has been added on without proper idea what for. Accessibility can be poor either due to lack of user friendliness or trained users. The end-user motivation to use smart solutions depends on how beneficial the solution is for the user and if it has the added value of making things easy-going or comfortable (the EU Elderathome survey in Himanen [44], the EBOB project in Himanen et al. [48]). The usage is dependent on limitations and possibilities. The possibilities are offered by technology, but the limitations can be both technical and social and psychological.

As from the technological point of view the smart building would be rather made of active structures and technologies than passive collection of preset technologies.

Some point out that there is no technological limitation for digital ecosystem building such as that of the smart environmental development, for example. The holistic approach needs experts with skills in several disciplines and their cowork. However, human brain has been proven to be able to manage maximum from 5 to 9 issues at time (Miller [62]). How difficult it might be to virtualize our experiences, lot of advanced science is going on new methods to observe human cognition and to reach data or information of the transcendence or understand the essence of human wisdom.

The user involvement is problematic while engineering education does not touch it almost at all. It is important to understand that user involvement needs special expertise on it and that for example the serious gaming technology is not necessarily enough in scoping the user needs and desires. The issues are not made easier while the experts in psychology or social scientist do not necessarily speak same language with technocrats.

Nevertheless, exclusively trusting on end-users alone and either neglecting or forgetting the expert knowledge from traditional developers or suppliers can be rather problematic. While the user involvement in design and operational solutions has been intensified, the focus tends turn strongly on the end-user feedback and the interplay between the users and the experts, as well as, the role of the expert knowledge seems sometimes been forgotten.

The problem of the quality of sample has popped up. For example, or some living lab methods as such are considered good but trust on end-user feedback can be questioned when–they have been used by soliciting contributions on ideas of product or service innovations or content provision, from a large group of people without any special selection criteria, and especially from an online community. The interaction that takes advantage both form user and expert knowledge can yield to a win-win solution—superior over one-sided approach from any source.

The design of smart user-oriented build environment starts from the understanding the processes of the occupants' activities and related information flows with big data from sensors, in-house registers, weather information, etc. The ability to adjust to constant change forms the base of design and control.

As innovation on intelligent building all technological advancement can benefit from linkages of (big) data, applications, digital ecosystems of several disciplines but not necessarily integration algorithms by one operator. Failed attempts to produce a killer application to smart building market have appeared. The use of open source licensing in intelligent building has based on consortia of companies operating in a certain market segment of smart building technology. Even this strategy has not led to a worldwide de facto standard. Smart built environment accessible on web or compatible with web has postponed and the stabilized business has been kept and retarded the digitalization of smart built environment which comprises a major part of society.

A potential for future competitiveness in the smart technologies lies in interoperability and ability of real estate and building sector to follow up the progress in digital economy. Digitalisation is dramatically impacting way of working and the whole operation and business environment. Neglecting digitalisation will cause a risk of losing the game in the highly competitive markets. The business will change not lost. Digitalisation can bring new business opportunities, business models, change the roles of operators in a value chain, and end existing business.

There is a need to extended thinking beyond technological approach towards interconnected daily activities at home and our duties in working life as well as in service fusion overall.

It is not enough to limit digitization referring to the conversion of analogue data (as images, video, and text) or information in oral or paper form into digital form. This transformation, refers to the ability to turn existing products or services into digital variants, and thus offer advantages over tangible product and changes associated with the application of digital technology in all aspects of human society.

13.6 Conclusion

No wider systematic review study on how the implementation of intelligent building concept has progressed in building sector has been found when the concept is considered in its wider holistic content. However, there are yearly granted awards highlighting the best built environments after various criteria.

Although several organisations have attempted to establish a universal definition for smart building or smart city, there are a multitude of definitions with different levels of detail and varying degrees of emphasis on various aspects of building intelligence.

Still, since 1980s the progress in software development has been excellent, while at the starting point even any commercial Internet was not here yet. The technology push type progress of smart built environment has taken advantage of this development.

A study on the user feedback has proved intelligent office buildings superior over other high quality office buildings.

The smart building has been the promise of the future. Engineers have not given up of this approach. Today digitalization and platformization are the promise which can be expected to have results in the very near future.

The IT giants are interested in digitalization of societies together with startups and spin-offs that have popped up from the unsatisfied user needs in smart built environment.

Digitalizing societies include also the human dimension into the concept of effective use of ICT. This progress concerns both smart city and intelligent buildings. Connected society has it all and is ready for collaborative and digital economy.

Despite the non-existence of systematic review study on how the implementation of intelligent built environment sector has progressed a few reasons for the fact that the concept of smart built environment has not yet been fully employed in the practice can be summarized

- The starting point in the integration of technologies has dominated and promoted technology push approach which as such has been very good.
- Internet has taken the role of integrator and decreasing the meaning of sector dominant solutions. Consequently causing frustration and diminishing business opportunities of closed solutions. Utilisation of cloud-based application has been slow.

- Although buildings have always been built as a shelter for people, in general, the user-driven building sector in the modern sense is in infant stage and consequently, the smart technology alone does not appeal customers if provision of services on smart technology for built environment is lacking.
- Municipalities' role in digitalization of the society is remarkable, but some of them might have ignored the importance of end-users' in the development of e-service provision.
- A common ICT architecture for all seems to be in favour or in interest of noboby including a large client pool of real estate and building sector.
- The market of smart housing has not started fly general as expected, and for example in the elderly housing despite the long lasting work while they do not buy. On the other hand, studies show that elderly are by no means overlookers of new technology but they buy only when the technology is satisfying their customer expectations.
- Despite the existence of user friendly cloud-based solutions representatives of building sector keep on favouring siloed ICT solutions.

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