MJ2685 – Smart Cities and Climate Mitigation Strategies,
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Literature Review Assignment

Definitions of Smart Cities and their potential importance as a Climate Mitigation Strategy

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ABSTRACT AND SUMMARY

Smart cities are a necessary tool to drive our cities towards sustainability. The definitions of the concept are still very diverging. Some only describe the urban aspects that are influenced; others describe the technological implementation or only the purposes and goals it aims to achieve. A more comprehensive definition includes these three pillars in one definition, without excluding new ideas and new fields of application that come in along the way of design and implementation of a smart city. Therefore a new, more flexible, yet comprehensive definition is proposed.

The greenhouse effect is imminent. To stop the global warming trend at the 'acceptable' and 'intentional' level of 2°C, CO_2 –equivalent emissions should be decimated to almost zero-level. Drastic measures are needed if this intention is to become truth

Smart cities technology can definitely help climate mitigation to succeed. The efforts should not be limited to the implementation of smart cities; however it proves to deliver a lot of opportunities and it is therefore advisable to approach smart cities as on the necessary steps towards climate sustainability. To reduce the carbon footprint and mitigate climate change, the smart city technology is applicable for end use efficiency, renewables, the use of biofuels and it can have a positive influence on power plant efficiency. It can also be a drive towards benchmarking and education on how polluting we actually are. Further, an environmentally friendly economy can be constructed, based on the information and data the smart city provides.

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INTRODUCTION

'Smart Cities' is a brand new approach to urban development. It aims to provide an answer to some of the big challenges for the future. The urban population keeps on growing towards 70% of the global population of 9 billion people in 2050 (UNICEF 2012). In order to keep this evolution manageable, urban workings and organisation must drastically change, within a way that citizens win comfort and don't have to adapt their lifestyle too much. But also in a way that the environment is respected, safety and security is guaranteed, economy becomes more lucrative and government can govern a rising amount of people more efficiently. Depending on which definition is applied; the smart cities concept even goes beyond keeping the future manageable. It wants to make the future sustainable.

METHODS

In order to write this Smart City paper a literary review is performed using specialized handbooks, papers and internet resources. All the consulted material can be found in the reference list

CHAPTER 1: THE DEFINITIONS OF 'SMART CITIES'

The Smart Cities concept is still largely unexplored and not mapped in detail. There is not yet a clear understanding of what the concept specifically comprises. Everybody seems to define Smart Cities as suits best for their own purposes. A spectrum from totally non visionary and trivial descriptions to very ambitious and futuristic proposals can be found in literature. The progress of defining and clearly introducing the concept is still in progress.

A comprehensive, yet academic, overview of which areas the concept 'smart city' influences is given in the following array of disciplinary fields: management and organisation, technology, governance, policy context, people and communities, economy, built infrastructure and natural environment (Chourabi et al, 2011). It is important that the definition facilitates the smart city to take part in all these aspects. A practical and clearly implementable approach of smart cities translates the previous disciplinary fields into following practical aspects: traffic, energy and utilities, healthcare, airports, social services, education, rail, retail, communications, economic development and public safety (IBM, 2012).
If a definition is to be constructed, it should be compatible with all these previous aspects, both practical and theoretical. Also the purpose of the smart city concept should be highlighted to prevent the term from being wrongly applied or misinterpreted. Several working definitions have been formed throughout the last few years. Three diverging examples are given:

> *A city well performing in a forward-looking way in economy, people, governance, mobility, environment, and living built on the smart combination of endowments and activities of self-decisive independent and aware citizens (*Giffinger, 2007).
>
> *A smart city is a city connecting the physical infrastructure, the IT infrastructure, the social infrastructure and the business infrastructure to leverage the collective intelligence of the city* (Harrison 2010).
>
> *A city striving to make itself 'smarter' (more efficient, sustainable, equitable and liveable)* (NRDC, 2012)

The first definition identifies smart with the aspects of urban living to be addressed and optimized to create a forward-looking well performing city. The second one approaches 'smart' as 'technologically interconnected to leverage collective intelligence'. The third one only states the goals and associates 'smart' with attaining efficiency, sustainability, equitability and liveability. These are 3 very different approaches for defining 'smart cities'. However all three do they forget the aspects covered in the other two and are not comprehensively describing what a smart city actually is in its completeness.

Smart cities include countless aspects, numerous technologies and the implementation of the concept is very case specific. Every city will have a different optimal implementation. Therefore it is useless to try to define a smart city simply as a city that has a certain series of implemented technologies in city life. Additionally, without any quantification of the development goals, any city that even uses the slightest bit of information technology can call itself a smart city. A better approach would be not to only focus the definition on the technological and urban aspects of smart cities but on the goal it has to reach by implementing the smart city aspects.

> *"A Smart City is a city that successfully and efficiently implements the smart city physical, IT, public, social and business infrastructure in its daily urban workings to this extent that it facilitates intelligent city dynamics, intelligent energy dynamics and intelligent decision making in general; and through this way reaches agreed sustainable development goals"*

Or analogously, a city is smart when it applies sustainable urbanism through the extensive implementation of the smart city aspects and technology. It is important that the sustainable urban development goals are universally determined and negotiated on a realistic basis that encompasses sustainability in all its aspects.

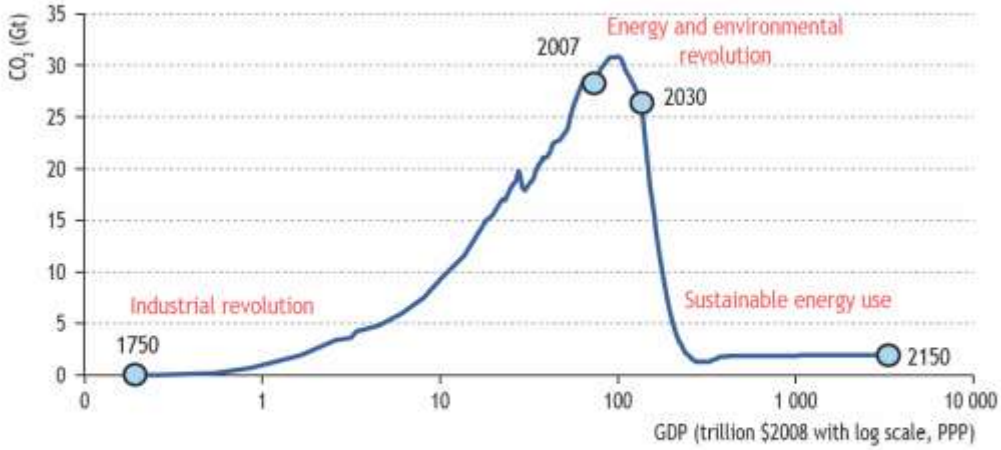
CHAPTER II: WHY SMART CITIES CAN HELP MITIGATING CLIMATE CHANGE

Among the aspects of smart cities are energy, industry (economic development) and transport in all their forms present in an urban area. As is well known, these three contribute for the largest part in the threat of climate change and global warming. Cleaner energy, industry and transport are needed to secure health, safety, and to preserve the environment. Air pollution with NOx, SOx, VAS, PM10, ozone induces health risks. Even in the unlikeliness of a nuclear accident, also radioactive substances can impose health and economic risks. The enhanced greenhouse effect is induced by the large amounts of CO_2 equivalent emissions that are related to energy, industry and transport. This last phenomenon is the one that poses the risk for climate change. For the planet, climate change is no problem. For the people who live in it, it is.

Why do we need to look at cities in order to mitigate climate change?

Cities worldwide are responsible for 70% of global greenhouse gas (GHG) emissions. Currently, anno 2012, the CO_2-equivalent concentration in the atmosphere is about 380 ppm. If the earth's temperature is to rise not more than 2°C above pre-industrialised levels, as was intentionally declared by the world leaders at the Copenhagen climate summit, the CO_2-equivalent concentration must not exceed 450 ppm. However, CO_2 remains in the atmosphere for about 100 years. This means that, on a shorter-than-100-years-term, even if the emission per year is held constant and doesn't increase, a linear rise in CO_2 concentration will be noticed. This also means that to saturate the concentration to the level of 450 ppm, the emissions must soon start decreasing very strongly and keep on decreasing until the emission level is almost at zero. The figure below illustrates this (IEA World Energy Outlook 2009). Remark that the figure only includes energy related emissions. The real amount of emissions is larger due to deforestation etc; however the evolution of the curve is the same. However, most of cities' GHG emissions come from energy related activities such as power generation, transport and industry.

Figure 4.3 • Historical link between energy-related CO_2 emissions and economic output, and the pathway to achieving a 450 Scenario



Note: The projected trend approximates that required to achieve long-term stabilisation of the total greenhouse-gas concentration in the atmosphere at 450 ppm CO_2-eq, corresponding to a global average temperature increase of around 2°C. World GDP is assumed to grow at a rate of 2.7% per year after 2030.

Source: IEA databases and analysis.

As cities are the main contributor to the GHG-emissions, they should be in the main focus for reduction. The main GHG emitting factors are power production, transport, and industry, all accounting for about 1/3 for total GHG emissions (Shrestha, 2010). Coincidence or not, these three aspects are all included in the concept of smart cities.

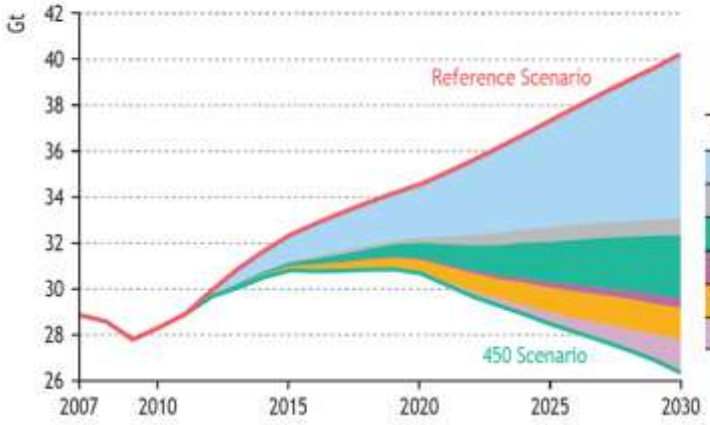
What do smart cities have that enables them to help the environment?

Smart cities encompass a series of communication technologies that have to be applied in the aspects of urbanisation. The employment of sensors and other data acquisition devices like cameras enable access to enormous amounts of data. Nowadays, a lot of useful information is lost, while actually it can be applied for the purpose of sustainable development, and with that, the reduction of GHG emissions. For example, the smart house receives and sends data to the smart grid. An intelligent system will then process this big amount of data (big data). Because of the huge amount of data, it must be handled in a very efficient way. The system will be able to draw conclusions by intelligently linking all applicable data measured in the city (linked data). The smart house can act and adapt its energy management for the benefit of the grid, the environment and your wallet, without disturbing your life's quality. Unless in case of emergency protocol, which will overrule for instance your laundry machine. Therefore, through better information exchange, it will be possible to take measures to reduce GHG emissions.

Where should the reductions be made, and how can Smart Cities help?

According to International Energy Agency (IEA) energy related GHG reduction should consist of several measures. As seen in the figure below, the main part of reduction should be in end-use efficiency. Another considerable part of reduction is accomplished by the deployment of renewable energy sources. Also the more nuclear energy would have a considerable positive impact. Further there is improvement of power plant thermodynamic efficiencies, biofuels and carbon capture and storage (CCS).

Figure 5.8 • World energy-related CO_2 emission savings by policy measure in the 450 Scenario



	Abatement (Mt CO_2) 2020	2030
Efficiency	2 517	7 880
End-use	2 284	7 145
Power plants	233	735
Renewables	680	2 741
Biofuels	57	429
Nuclear	493	1 380
CCS	102	1 410

For about 80% of the emission reductions we can apply smart cities solutions. Smart cities have the tools to positively influence the end-use of energy, the implementation of renewables, the production of biofuels and power plant efficiency.

- **End use**: By introducing the smart grid, smart metering smart houses, smart heating network, and increasing the transport efficiency, the smart city is the main driver for reduction in end use of energy. The smart grid can swiftly communicate info of smart metering in order to optimise the energy use of the smart houses. The smart house can run the household in such a way that the carbon footprint is minimized. Also smart heating systems will be able to heat the smart houses in a more efficient way. The economic concept of Negawatts (energy consumption that was avoided) will be introduced with smart technology. Transport energy use can be reduced by smart city systems that avoid traffic jams, or calculate the most fuel efficient route to follow. Also smart cities will have an improved public transport system, so it will be more beneficial to make use of it. Public

transport is nearly always environmentally beneficial when compared to individual cars. Public transport will use real time data to dynamically solve problems, keep the schedules, and improve the schedules.

- **Implementation of renewables:** Renewable energy sources (RES) and distributed generation (DG) account for very little GHG emissions (except the DG turbo diesel generators). In order to implement a considerable amount of RES and DG, a smart grid is needed. The flow of energy will now be multidirectional instead of unidirectional from the plant to the user. The smart city will enforce the concept of prosumers. With the traditional grid the amount of prosumers is restricted due to technical difficulties which can be overcome by smart technology.
- **Production of biofuel and re-use of waste:** The production of biofuels, biogas, and heat out of waste products is not a smart city application as such; however smart city applications are beneficial for the organisation of these processes. For example a smart city would be able to forecast the amount of energy that will be recovered from the waste streams, and the amount of extra gas and fuel that is needed is then predictable, allowing the market to act very efficiently and resulting in minimal waste of fossil resources.
- **Power plant efficiency:** Making a power plant inherently more efficient is not a smart city application as well. However smart technology and better communication in the smart grid would allow, under very strict circumstances and regulations, a reduction of the plants that have to operate at part load. Plants operating at part load have severe losses of efficiency. If the smart grid is implemented without paying attention to the part load operation of power plants, the related emissions will rise.

Monitoring, feedbacking and benchmarking

With smart technology it will be possible to monitor GHG emissions and detailed reports of GHG management of the urban area will be provided. Where are the big polluters? What do we have to do to improve? With the data available through the implementation of sensors and data communication we will be able to make detailed analysis and propose efficient but also cost effective solutions. The information that is available can also be dispatched to the polluter itself and raise awareness of their behaviour. The ability to benchmark to other families, companies and individuals can be made possible.

Better information for the economic system and enabling the introduction of price incentives

With the available data, and information, it will be possible to re-organise the economic development of a city and the way it treats its consumer goods. The real damage cost of consumer goods will become clear as the smart city will be able to monitor the whole lifecycle environmental impact from the production to the waste disposal or processing for re-use. A pricing system could be organised where damage cost is included in the product price. This could be organised as a varying part of VAT. This enforces environmentally friendly products to become economically more interesting and gives polluting products an economic drawback. For instance, two identical cars are produced. The first plant fully applies closed loop system, recovering all energy and waste material. The second made no such investments. The difference in ecologic footprint will be monitored by the smart city system. This way intelligent and innovative pricing can be introduced as a lubricant to sustainable consumption.

CONCLUSIONS

Smart cities are a necessary tool to drive our cities towards sustainability. The definitions of the concept are still very diverging. Some only describe the aspects that are influenced; others describe the technological implementation or only the purposes and goals it aims to achieve. A more comprehensive definition includes these three pillars in one definition, without excluding new ideas and new fields of application that come in along the way of design and implementation of a smart city.

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biofuels and it can have a positive influence on power plant efficiency. It can also be a drive towards benchmarking and education on how polluting we actually are. An environmentally friendly economy can be built on the information and data the smart city provides.

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