

BEUTH HOCHSCHULE
FÜR TECHNIK
BERLIN

University of Applied Sciences

Beuth-Sprachenpreis 2012



Matching Solutions

Ideas for Sustainable Cities of the Future

Henning Müller (759917)

Food Science and Technology Bachelor

henningmueller1987@gmail.com

Table of Contents

- Table of Contents I
- List of Figures II
- 1. Introduction – The Necessity of Sustainable Cities 1
- 2. The Way to Sustainability 2
- 3. Sustainability in Cities 3
 - 3.1. Energy and Water Use 3
 - 3.2. City Planning and Architecture 6
 - 3.3. Human Transportation 8
- 4. Matching Solutions 9
- Bibliography III
- Pictures V

List of Figures

Picture 1: Urbanization 1

Picture 2: The Three Pillars of Sustainability 2

Picture 3: Global Cumulative Installed Wind Capacity 1996-2011 3

Picture 4: Gujarat Solar Park, India 4

Picture 5: Possible Water Savings 5

Picture 6: Dickson Despommier's Vertical Farming 6

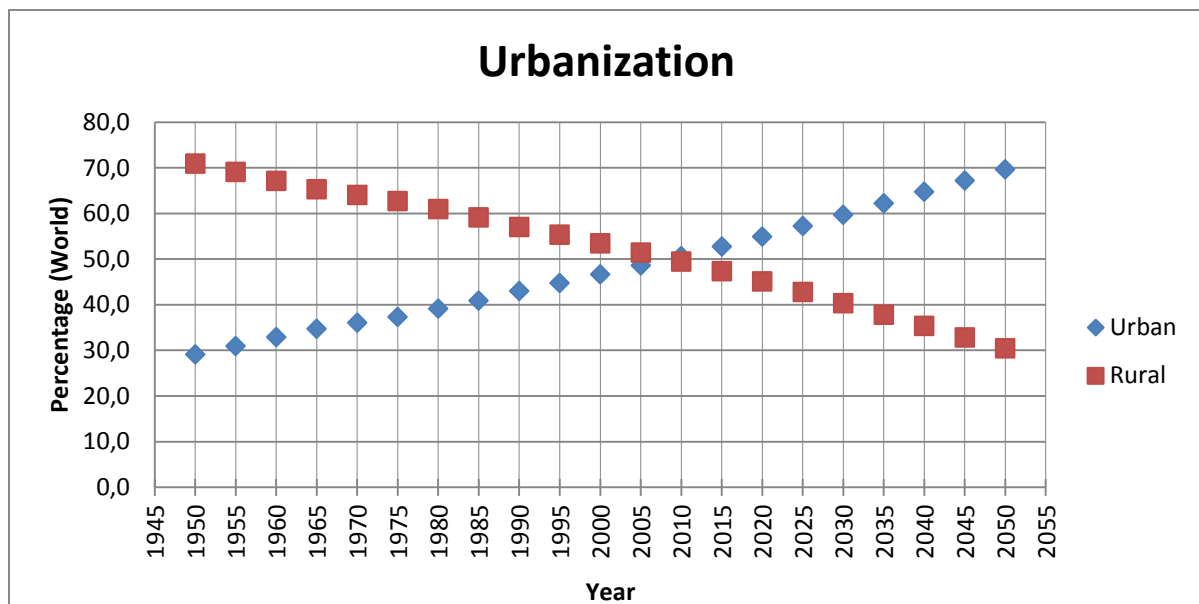
Picture 7: Matching Solutions 9

Picture 8: Transparent Solar Cell (right) in Comparison with Window Glass (left) 10

1. Introduction – The Necessity of Sustainable Cities

“Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”¹

Sustainability has gained rising importance within the last quarter of a century. The *Brundtland Report* (“*Our Common Future*”) by the *World Commission on Environment and Development (WCED)* was published in 1987 and is considered as the first important global political document that focuses sustainability as a major topic.² Later on, the necessity of sustainable development was highlighted in the *Rio Declaration (UN, 1992)*, the *Agenda 21 (UN, 1992)* and the *Johannesburg Declaration (UN, 2002)* as well as in several other official documents.



Picture 1: Urbanization³

“The future health of our planet will be determined in our cities”. Regarding these words of Maurice Strong⁴ and the physical growth of urban areas (*Picture 1*), the significance of sustainability in cities becomes unambiguous.

This document is supposed to constitute the current situation and give ideas to realize sustainable cities of the future.

¹ Brundtland Report, p. 37

² Becker (2012), p. 1

³ Data: Homepage of the UN

⁴ Chairman of the Advisory Board for the Institute for Research on Security and Sustainability for Northeast Asia and a former undersecretary general of the United Nations, *04-29-1929

2. The Way to Sustainability

According to the *2005 World Summit* sustainability is based on three main pillars.



Picture 2: The Three Pillars of Sustainability⁵

Environmental protection is the classical leading thought of sustainability. It aims on the use of natural resources without sacrificing the ability of future generations to meet their own needs.

The purpose of *economic development* is to utilize available resources to best advantage. The Main idea is to increase the usage of efficient and responsible resources to provide long-term benefits. A society is considered as economic sustainable if it can persist durable.

Social development focuses social inconsistencies. The Brundtland Report reveals poverty as “a major cause and effect of global environmental problems”⁶. Social disruptions should be eliminated because they divert resources from areas of greatest human need⁷. It is proven that the crime rate is dependent on the level of education⁸.

Only with simultaneous consideration of all three pillars the achievement of long lasting sustainability becomes possible.

⁵ 2005 World Summit Outcome Document, p. 2

⁶ Brundtland Report, p. 12

⁷ Blewitt (2008), p. 96

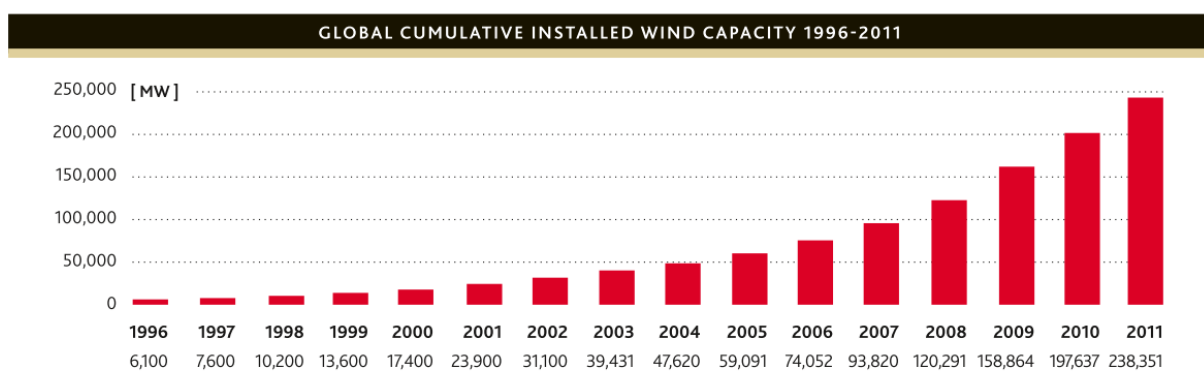
⁸ Lochner et al. (2003), p. 24

3. Sustainability in Cities

In 2008 the proportion of people who lived in urban areas reached 50% for the first time in history⁹. Due to steady growth it is expected to reach 70% in a few decades¹⁰. Therefore, the creation of cities “whose residents used no more than their share of the earth’s resources than what our globe can reasonably endure”¹¹ receives increasing importance. Due to the diversity of impacts on the sustainability of a city this chapter is divided into the main categories that have to be focused during the way to sustainability. These are no strict boundaries but smooth transitions.

3.1. Energy and Water Use

The goal of sustainable cities is to avoid an ecological footprint and to achieve a state of zero emission. Therefore, it is essential to get away from fossil fuels which need millions of years to regenerate¹². Using energy which comes from natural resources such as wind, sunlight, geothermal heat, biomass heat and hydropower is the prevailing alternative. A city can ideally be supplied with one hundred percent energy from renewable resources. Depending on the location and the climatic conditions the most efficient method(s) for each city must be chosen. This chapter will focus a selection of important energy sources for sustainable cities.



Picture 3: Global Cumulative Installed Wind Capacity 1996-2011¹³

⁹ J. Zhao (2011), p. 1

¹⁰ Christian (2004), p. 453

¹¹ Höjer et al. (2011), p. 3

¹² Mann et al. (2003), p. 50

¹³ Global Wind Statistics (2011), p. 3

With a proportion of 2.5% of the total worldwide electricity usage and an annual growth of 25% wind power is an increasingly encountered renewable energy.¹⁴ The Scotsman James Blyth was the first who used a windmill to generate electricity for charging batteries for electric lighting in 1887.¹⁵ During the technical development in the last decades wind turbines became more efficient and gained rising importance. Wind farms were built on- and offshore to produce thousands of megawatts output power. The largest onshore wind farm is the *Gansu Wind Farm* located in China with over an output power of over 5,000 MW¹⁶. The goal to reach 20,000 MW by 2020 is a perfect example of the future development of this kind of renewable energy. The *Alta Wind Energy Center* in California (1020 MW) is the largest onshore wind farm outside of china.¹⁷ Concerning the world wide total capacity of wind power, Germany is (with a share of 12.2%) on the third position after China (26.3%) and the USA (19.7%)¹⁸.

Another increasingly relevant type of sustainable energy is solar power. Photovoltaic



Picture 4: Gujarat Solar Park, India

cells are used to convert solar radiation into electricity by using the photoelectric effect¹⁹. The *Gujarat Solar Park* in India is the world's largest photovoltaic power plant with an output of 214 MW and the capacity to 500 MW.

At the end of 2011 solar photovoltaics produced

worldwide 69,684 MW and this number is expected to rise to 342,810 MW until 2016²⁰. Today, 0.5% of the world electricity demand is covered by photovoltaics²¹.

¹⁴ International Energy Outlook, p. 66

¹⁵ Price et al. (2004)

¹⁶ China Daily (2010)

¹⁷ Terra-Gen Press Release (2010)

¹⁸ Global Wind Statistics (2011), p. 3

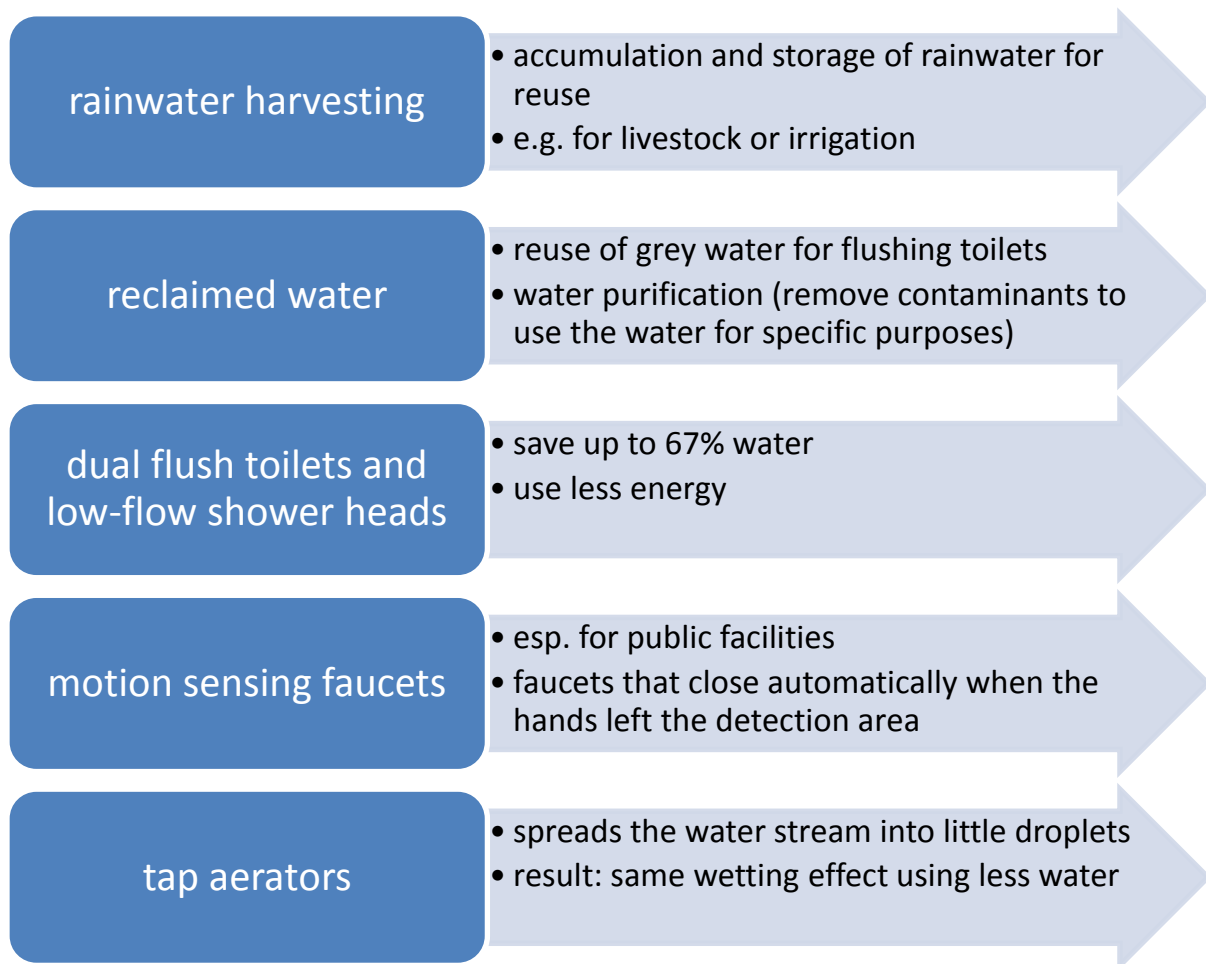
¹⁹ Grometstein (1999), p. 183

²⁰ Global Market Outlook for Photovoltaics until 2016 (2012), p. 45

²¹ Global Market Outlook for Photovoltaics until 2016 (2012), p. 62

Another application area of solar energy is water heating. Solar collectors are fastened to the roof of a house to absorb the heat of the sun. The hot water is sent to a storage tank from where cold water is transported back to the roof.

To ensure the availability of water for future generations, sustainability does also include the minimization of water use and the recycling of waste water. Minimizing the consumption of water does also implicate a reduced wastage of energy due to less water transport, pumping and waste water treatment. The following chart will give a selection of possibilities to integrate water-saving objects into sustainable households.



Picture 5: Possible Water Savings^{22 23}

²² Colorado Water Conservation Board (2010), p. 8

²³ Department of Sustainability and Environment (2012)

3.2. City Planning and Architecture

“Contrary to common belief, urban systems can be more environmentally sustainable than rural or suburban living.”²⁴ This conclusion arises from the possibilities of close settlement. Living without a car is much easier in a dense city with a good infrastructure than it is in rural areas with long distances. Instead of heating many independent houses separately, multi-family buildings can share more efficient heating systems.

Especially the structure of a city makes it more or less energy efficient. Integrating areas of agriculture into a city opens the possibility to feed its residents with locally produced foods. As a result the food quality rises, jobs are created and the costs decrease due to economized transportation routes²⁵. Dickson Despommier is a

Professor at the *Columbia University in the City of New York* and became known for his idea of “vertical farming”²⁶. The idea is to create “Bioclimatic Skyscrapers” which combine living units and green areas used for farming or even build pure “Farmscrapers”.

These indoor farms are closed systems that make it possible to farm independent of seasons. It’s not only possible to increase



Picture 6: Dickson Despommier's Vertical Farming

²⁴ López-Mosteiro (2011), p. 4

²⁵ Jack Smit et al.

²⁶ Despommier (2010)

the harvest volume²⁷ but also to decrease the necessary water by using closed water cycles and growing plants in nutrient solutions. Additionally, gray water can be used and converted into drinking water by collecting the water of evapotranspiration²⁸.

To achieve the highest possible energy efficiency the relative positions of functional buildings have to be considered. Workplaces have to be close to residential areas. This “reunification of home and work”²⁹ shortens distances and enables the use of factory “waste” for secondary benefits. Gray water of plants can be reused to flush toilets in private households and steam connections to provide heating³⁰. Housing blocks can be designed for multi-functional use. Rooftops are predestined to be used as green spaces for relaxation or to be covered with solar cells to produce energy. One aim of sustainability is to realize “net-zero energy buildings”. These buildings produce as much energy as they use over the course of a year³¹. This is possible by producing energy from renewable sources like solar power or ground heat in combination with very high levels of insulation. Airtightness around doors and windows and the heating systems play a decisive role to be more temperature efficient.

Despite the minimization of carbon dioxide by implementing the aforesaid prospects there always is a certain production of carbon dioxide. Therefore, it is necessary to plant trees to offset locally generated greenhouse gas emissions³². Urban forestry maintains biochemical cycles as well as it has aesthetic reasons like beauty and providing shade.

²⁷ Despommier (2008)

²⁸ Despommier (2008)

²⁹ Höjer et al. (2011), p. 102

³⁰ Lowe (2001)

³¹ U.S. Department of Energy (2006), p. 5

³² Slavin (2011), p. 15

3.3. Human Transportation

Fossil fuels (30%) and the industry sector (15%) are the main sources of carbon dioxide emissions. Transportation (only road transport!) is on the third place with a portion of 14%³³. Therefore, it is important to integrate an efficient system for human transportation into a city to minimize CO₂ emissions and the consumption of energy.

The last chapter described the optimal structure of a sustainable city (high density). Residents should usually live in proximity to their working places. This allows the infrastructure to be more efficient. Short distances can be walked or rode by bike. For longer distances public transportation must be ubiquitously accessible. Regardless of from where and to where people want to go – they must be easily able to reach their destination using public transportations. An important requirement to make people use the local public transport is the affordability. The costs must be appreciably lower than using the car. A potential to widen the distances between locations of available public transportation is to provide the possibility of bicycle transportation or parking. People can reach stations easily by bike (even if they are not in walking distance) and take their bicycles into the trains to go on riding after arrival. To make people consider using the bicycle to reach public transportations stops they should include places where bicycles can be placed safe. Additionally bicycle sharing stations can be placed at stations in the city core. These can be used to cover distances in the inner city. Beside a program for the expansion of bicycle transportation San Francisco has launched a citywide car-sharing service³⁴. Members can easily reserve cars by phone or online and just use their personal key chain to open the doors of any reserved car³⁵.

Reorganizing urban traffic is possible by several mechanisms. Increasing fuel prizes or implementing road charges for the city core are imaginable. A reduction of carbon dioxide emissions can be done by implementing “low emission zones” that ban vehicles that exceed a critical value. People are forced to buy low emission vehicles or switch to green transportation like walking, bicycling or public transportation.

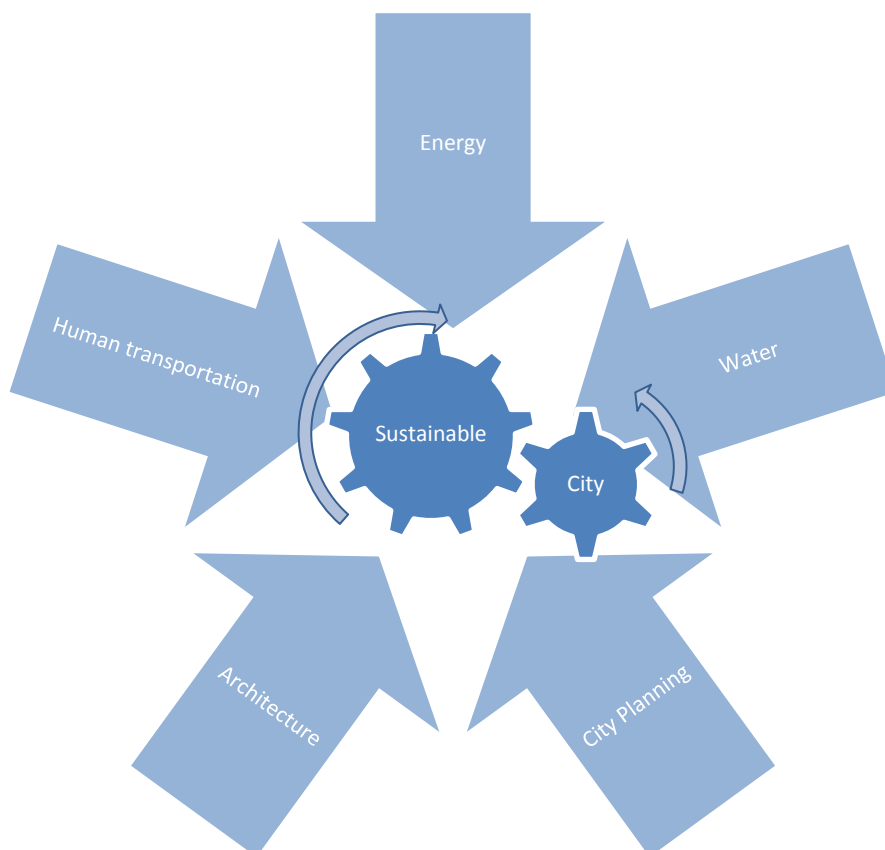
³³ European Commission (2000)

³⁴ Slavin (2011), p. 13

³⁵ City Car Share (2012)

4. Matching Solutions

It is known how to use energy and water efficiently, how to plan and built cities and how to arrange human transportation. What is needed, is a more efficient way to match solutions to future challenges. A sustainable city of the future is a place where all solutions will be realized to “meet [...] the needs of the present without compromising the ability of future generations to meet their own needs.”³⁶



Picture 7: Matching Solutions

includes sustainable solutions for all the points from *Picture 7*. Functional areas are placed tactically to reach a highly efficient infrastructure. Organizations should be connected to work together to improve their economic performance³⁸.

Considering all topics from the last chapters it is still a challenge to establish sustainability regarding “that most cities [...] have already been built and it is becoming crucial to find ways in which to make them function sustainably”³⁷.

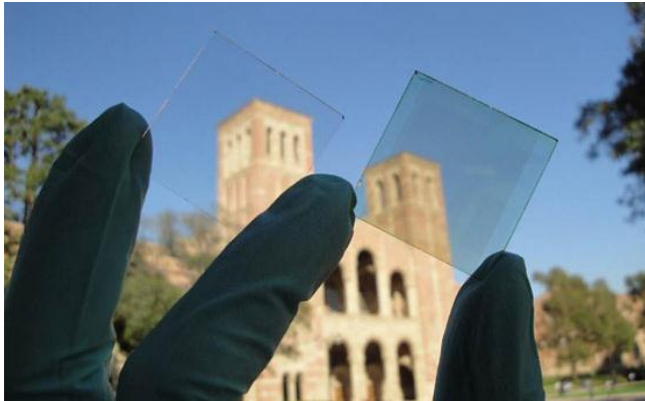
Building up a city from zero

³⁶ Brundtland Report, p. 37

³⁷ Herbert Girardet, World Future Council (2008)

³⁸ Lowe (2001)

Vertical Farms with transparent solar cell windows and methane digesters to produce their own electrical needs are placed in the city core. Buildings are made of



Picture 8: Transparent Solar Cell (right) in Comparison with Window Glass (left)

sustainable materials. Bamboo is one of the fastest-growing plants on Earth with growth rates that can reach 100cm per day.³⁹ Houses can be built of composite materials of bamboo and recycled material. To ensure good insulation characteristics obligatory standards have to be set. The realization of these standards requires certification systems which ensure

the energy efficiency of buildings. This does not only apply for buildings but also for electronic devices like TVs, computers and washing machines. Only low- or even zero-emission-cars and fuel efficient transportation vehicles in public transportation should be allowed to be used in the city core. To widen the access cover of public transportation, save parking areas for bicycles and cars must be placed next to stations. Public transportation must be designed for bicycle entrainment. Bicycle sharing systems which you can use at least 30 minutes at no charge must cover the whole city core to give people an easy possibility to travel short distances. Governmental subsidies should support sustainable appliances and classical technologies must be increasingly banned. Solar- and wind parks around the city must be able to cover the basic need of energy.

The main challenge of implementing all these aspects into an existing city is to ingrain sustainability into the resident's brains. Getting back to the three pillars of sustainability (*Picture 2, p. 2*) education is an essential key on the way to sustainability. People have to know why a sustainable lifestyle is important and how every single citizen can contribute its part.

³⁹ Farrelly (1984)

Bibliography

Becker, Christian U. Sustainability Ethics and Sustainability Research. New York: Springer, 2012.

Blewitt, J. Understanding Sustainable Development. London: Earthscan, 2008.

Christian, D. Maps of time: an introduction to big history. Berkeley: University of California Press, 2004.

City Car Share. City Car Share. 2012. <https://www.citycarshare.org/what-is-car-sharing/howitworks/> (Retrieved 09-06-2012).

Colorado Water Conservation Board. „Authorization of Pilot Projects for the Beneficial Use of Captured Precipitation in New Real Estate Developments Criteria and Guidelines for the "Rainwater Harvesting" Pilot Project Program.“ 28. January 2010. <http://cwcb.state.co.us/legal/documents/guidelines/finalrainwaterpilotcg.pdf> (Retrieved 09-02-2012).

Department of Sustainability and Environment. Using & Saving Water. 01. July 2012. <http://www.water.vic.gov.au/saving/home/rebates/home-and-garden-rebates/products> (Retrieved 09-02-2012).

Despommier, Dickson. The Vertical Farm. 2008. <http://www.verticalfarm.com/more> (Retrieved 09-04-2012).

Despommier, Dickson. The Vertical Farm: Feeding the World in the 21st Century. Thomas Dunne Books, 2010.

Energy Information Administration. International Energy Outlook. 2006.

European Commission. „Emission Database for Global Atmospheric Research, Edgar;.“ 2010. http://edgar.jrc.ec.europa.eu/overview.php?v=CO2ts_pc1990-2011 (Retrieved 09-05-2012).

European Photovoltaic Industry Association (EPIA). „Global Market Outlook for Photovoltaics until 2016.“ May 2012. <http://files.epia.org/files/Global-Market-Outlook-2016.pdf> (Retrieved 08-29-2012).

Farrelly, David. The Book of Bamboo. Sierra Club Books, 1984.

Global Wind Energy Council (GWEC). „Global Wind Statistics 2011.“ 07. February 2012. http://www.gwec.net/fileadmin/images/News/Press/GWEC_-_Global_Wind_Statistics_2011.pdf (Retrieved 08-29-2012).

Grometstein, Alan. The Roots of Things. New York: Kluwer Academic, 1999.

Höjer, Mattias, Anders Gullberg, und Ronny Pettersson. Images of the Future City - Time and Space For Sustainable Development. New York: Springer, 2011.

Lochner, Lance, und Enrico Moretti. The Effect of Education on Crime: Evidence from Prison Inmates, Arrests and Self-Reports. Los Angeles: UCLA, 2003.

López-Mosteiro, Natalia Franquet. „Urban Knowledge, The city is the key to face the problems of our time...“ 2011.
<http://www.ess.co.at/SPATIALPLANNING/NataliaFranquet.pdf> (Retrieved 09-02-2012).

Lowe, Ernest. Eco-industrial Park Handbook for Asian Developing Countries. Oakland: Indigo Development, 2001.

Mann, Paul, Lisa Gahagan, und Mark B. Gordon. Giant Oil and Gas Fields of the Decade, 1990-1999. Kansas City: American Association of Petroleum Geologists, 2003.

Nisson, Ned, und Gautam Dutt. The Superinsulated Home Book. Michigan: John Wiley & Sons, 1985.

Price, Trevor J., und Matthew Brian Harrison. Oxford Dictionary of National Biography, from the earliest times to the year 2000. Oxford: Oxford University Press, 2004.

Slavin, Matthew I. Sustainability in America's Cities - Creating the Green Metropolis. Washington DC: Island Press, 2011.

Smit, Jack. Urban Agriculture for Sustainable Cities: Using Wastes and Idle Land and Water Bodies as Resources.

„Terra-Gen Press.“ 17. April 2012. [http://www.terra-genpower.com/News/Terra-Gen-Power-Announces-Closing-of-\\$650-Million-.aspx](http://www.terra-genpower.com/News/Terra-Gen-Power-Announces-Closing-of-$650-Million-.aspx) (Retrieved 08-29-2012).

U. S. Department of Energy. Zero Energy Buildings: A Critical Look at the Definition. California: National Technical Information Service, 2006.

UN. „2005 World Summit Outcome.“
<http://www.who.int/hiv/universalaccess2010/worldsummit.pdf>, 2005. (Retrieved 08-30-2012).

WCED. Brundtland Report / Our Common Future.
http://conspect.nl/pdf/Our_Common_Future-Brundtland_Report_1987.pdf, 1987.
(Retrieved 08-30-2012).

Xinhua, China Daily. Jiuquan wind power base completes first stage. 04. November 2010. http://www.chinadaily.com.cn/bizchina/2010-11/04/content_11502951.htm
(Retrieved 09-01-2012).

Zhao, Jingzhu. Towards Sustainable Cities in China. London: Springer, 2011.

Pictures

Picture on cover page:

http://www.warrensyste.msinc.com/wp-content/uploads/2012/04/green_earth1.jpg

(Retrieved 08-18-2012)

Picture 1: Urbanization:

Data: Homepage of the UN, <http://esa.un.org/unup/>

(Retrieved 08-29-2012)

Picture 4: Gujarat Solar Park, India:

<http://www.guardian.co.uk/environment/picture/2012/may/02/gujarat-solar-power-park-india#zoomed-picture>

(Retrieved 08-31-2012)

Picture 6: Dickson Despommier's Vertical Farming:

<http://www.verticalfarm.com/designs?folder=fa7bdf4e4-03c5-49ed-b1aa-9911dd75d287>

(Retrieved 09-04-2012)

Picture 8: Transparent solar cell (right) in Comparison with window glass (left):

<http://www.blogcdn.com/www.engadget.com/media/2012/07/transparent-solar-cell.jpg>

(Retrieved 09-05-2012)