NGI101x - 5.3 - Urban infrastructure Part 2

As you have seen last week, smart meters and smart grids can contribute to Increasing energy awareness and in educating citizens and industries in energy saving behavior.

While Sonderborg is on its way to become carbon neutral, dense megacities will for the time being rely on renewable energy sources harvested outside the city. However, they can do a lot more towards energy efficiency in transport (public transport) and the built environment. In the building frenzy of many of today's megacities, building quality is insufficiently enforced, even if strict quality standards are formally in place. This is bad news for many years to come, as the potential for energy efficiency for the next decades is largely determined by the building practices of today.

In dense megacities, infrastructures for the supply of safe drinking water and the hygienic removal of waste and waste water are arguably the most crucial for the citizens' wellbeing, as they are crucial for public health. Untreated waste and waste water are potential sources of disease, including contagious diseases. In 2007, the readers of the British Medical Journal elected sewerage as the most crucial 'medical' breakthrough in the past 200 years. Waste and waste water must not only be treated for reasons of public health. It is also necessary to protect the local environment and its ecosystems and, moreover, waste and waste water are becoming more and more important as sources of secondary raw materials. Waste water is a source of phosphate, needed as a fertilizer in agriculture, and the solid waste produced by cities is a source of useful minerals and valuable metals.

The problem with cities, and especially with megacities, is that their concentrated population mass puts excessive strain on the local environment, in terms of water and energy needs as well as the generation of emissions, waste and waste water.

[Slide 20] In practice, much more than just the local environment is affected: in a world of global supply chains, a major part of the city's water and energy use is happening where the city's food and goods are produced. Agriculture is responsible for 70% of the world's freshwater use, industry for 19%, whereas domestic use accounts for only 11%. However, think of the water footprint of the products you use every day: a liter of milk has taken 1000 liters of water to produce. The footprint of a new pair of jeans is 11,000 liters of water, as it takes 10,000 liters of water to produce a kg of cotton.

The Aral Sea disappeared because the rivers feeding it were diverted for irrigation projects – among others to irrigate cotton plantations. It is now known as one of the planet's worst environmental disasters.

The sad truth for many megacities in coastal zones is that they satisfy their freshwater needs by extracting groundwater at rates that far exceed the rate of replenishment, with serious adverse consequences, such as salt water intrusion and land subsidence, see for example what happened in Jakarta over the past 40 years.

In a world in which more than 50% of the population already lives in coastal zones, the combination of sea level rise and land subsidence is bad news, as it entails more exposure to the risk of flooding.

Salt water intrusion implies that groundwater becomes increasingly brackish, so that more and more energy intensive and expensive desalination techniques are necessary to make the water drinkable. Desalination is technically possible and widely practiced, especially on Caribbean and Mediterranean islands and in the Middle East region. However, desalination is energy intensive, and very expensive, which may not be a problem in oil rich Sauda Arabia, but which is a serious problem in many emerging economies.

Especially in water strained locations, the city's water needs often conflict with the water needs of agriculture and local ecosystems. As water is a prime condition for life on earth, cities have historically always been located in areas where fresh water was available in abundance. Whole civilizations disappeared when their water resources ran out. In river deltas, fresh water is available from rivers. The choice to use groundwater instead is usually made because of its better and more constant quality, so that it is less expensive to turn it into potable water.

In many emerging economies, surface waters are heavily polluted as a result of untreated or insufficiently treated discharge of industrial and municipal waste water. Agricultural pollution caused by the application of pesticides and fertilizers also poses a threat, both to surface water quality and future groundwater quality.

The water balance in cities can to some extent be restored by designing for water retention in the city. Rather than collecting and discharging rainwater runoff as quickly as possible, it could be allowed to seep into the soil so that, in time, it will replenish groundwater resources. Impermeable pavements could be replaced with porous materials. Green park areas which also offer water storage options, also contribute to restoring the water balance as well as to the quality of the living environment for the city's residents. Such measures help to some extent to maintain freshwater pressure in aquifers, thereby reducing salt water intrusion, and ensuring that natural ecosystems are not bereft of fresh water.

The challenge for cities is to meet the water demand as far as possible with renewable internal freshwater resources, which are internal river flows and groundwater from rainfall in the country. Since most large cities far exceed their renewable water capacity, it is the more important to raise people's awareness of water scarcity, and to advocate frugal water use, for example with the use of water saving fixtures. In some countries, such as Ireland, water use is not yet metered and charged, which is a practice that is not conducive to responsible water use. To build and maintain a high quality water infrastructure, the costs should be covered by all its users. Without metering and charging water use, consumers are not stimulated to reduce wastage. Without cost recovery, maintenance of the system will suffer. In Ireland it is estimated that more than 40% of the potable water produced by the water utilities is lost as a result of leaking distribution infrastructure.

The most extreme measures to guarantee water security are seen in Singapore, where waste water is processed and purified to the extent that it is restored to drinking water quality. For this purpose, Singapore uses microfiltration and reverse osmosis, both advanced membrane separation techniques. The drinking water reclaimed from waste water is known as 'NEWater' in Singapore. Even if it is absolutely safe, free from bacteria and even virus particles, most people do not like the idea that they are drinking used water, which is the reason that NEWater is currently supplied to industries for non-potable water use. At this moment in time, NEWater already meats 30% of the Singaporean water needs. By 2060, Singapore plans to have tripled the NEWater capacity, so that NEWater then supplies 55% of the projected water demand.

Hong Kong uses another interesting approach to reduce its freshwater footprint. Around 80% of Hong Kong residents flush their toilets with seawater, and in the spring of 2014 plans were announced to expand the seawater supply infrastructure to 85% of the Hong Kong population. Even though the seawater is only used for flushing, it is treated to ensure that it is bacteriologically safe. The construction of the seawater distribution system was started in the 1950's, to cope with the frequent shortages of freshwater. Both Hong Kong and Singapore have extensive schemes in place to protect the quality of their raw water reservoirs.

The UN World Water Day 2014 focused on the water-energy nexus: energy is needed for water, and water is needed for energy. You may be thinking here of hydropower, but in fact, for all thermal power plants, cooling water is an essential requirement. If it is not available in sufficient quantities, plants are forced to reduce their output or to shut down entirely. Energy depends on water – not only for power generation, but also for the extraction, transport and processing of fossil fuels, and the irrigation of feedstock crops for biofuels. Moreover, many low-carbon energy technologies – nuclear power, power plants fitted with carbon capture and storage equipment and certain types of concentrating solar power – can also be highly water-intensive.

Global water withdrawals for energy production in 2010 were estimated at 583 billion cubic metres (bcm), or some 15% of the world's total water withdrawals. Of that, water consumption – the volume withdrawn but not returned to its source – was 66 bcm. In the OECD/IEA scenarios for the future, withdrawals increase by about 20% between 2010 and 2035, but consumption rises by a more dramatic 85%.

Water is growing in importance as a criterion for assessing the physical, economic and environmental viability of energy projects. Among other examples, the availability of and access to water could become an increasingly serious issue for unconventional gas development and power generation in parts of China and the United States, India's large fleet of water-dependent power plants, Canadian oil sands production and maintaining reservoir pressures to support oil output in Iraq. Such vulnerabilities will require deployment of better technology and greater integration of energy and water policies.

Then, there is one more interdependency that I would like to point out, and that is the dependency of many innovative energy technologies on scarce materials. The materials developed for example for high efficiency wind turbines, batteries, solar PV panels and fuel cells, often contain so-called rare earth elements and other scarce materials. How to secure the supply of these critical materials is a concern for the future. Most of our recycling systems are far from effective: many valuable and critical materials leak away into the environment, due to a lack of public awareness, a lack of waste collection systems, and a lack of sophisticated waste processing systems. This will need to change. As the world population and its material needs grow, the waste generated by cities will become a more and more important source of critical materials.

Finally, let me get back to the factor 8 question: 'Is it possible to imagine infrastructure systems that can meet the needs of twice today's population with half today's resources while providing twice the liveability?'

Can infrastructure be the agent of change that helps cities to achieve this goal – and help us to balance the needs of the city with the needs of the natural environment and its ecosystems?

As you have seen today, the design and management of urban infrastructure is key to accomplishing the factor 8 goal. Infrastructure can serve us more economically and efficiently than we could do it ourselves, and it has to do so, so that cities can reduce their ecological footprint. Smart infrastructure can give us feedback on our behavior as consumers and thus help us to use natural resources more sparingly. By connecting us, infrastructure can support collaborative initiative and inclusive development.

Thank you for your attention.