Leverage Smart Utility Networks to benefit Aerotropolis

Since 2008 humanity is officially and urbanized species. Homo Urbanus consumes 75% of energy in buildings and transportation [Battle 2006]. Thus, the key to finding solutions to the effects of climate change is to be found in urban areas. This article focuses on the aerotropolis with at their core the airport. It explores how these regions can leverage the dynamics of our global economy and the development of smart utility networks to become resilient urban regions. In doing so the article gives a holistic perspective and identifies three key drivers.

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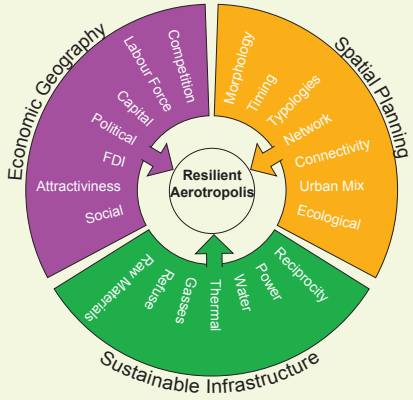
Since 2008 humanity is officially and urbanized species, often dubbed homo urbanus, with over 50% of all people living in urban areas. According to the United Nations, the world population is expected to increase from 7 billion to over 9.3 billion by 2050, a 40 percent increase in less than 40 years. The number of urban dwellers is expected to rise from 3.6 to 6.3 billion while rural regions will see their population drop by 300 million within the same time period [Worldbank, 2009].The densification of human settlement is also reflected in the fact that 75% of the world energy is consumed by buildings and transportation [Battle 2006] and that cities emit two-thirds of the world's greenhouse gas emissions. Because cities are expected to take the largest part of population growth for the coming future, urban productivity will need to intensify [Florida, 2013]. The modern globalized economy is defined by roughly 400 'global cities' [PWC, 2005] that have undergone 'denationalization' whose urban ingenuities (i.e. infrastructures, services, economy and social values) are more similar to one another than to other cities and towns found within their national boundaries. This number will rise to and adapting to climate change" [Timmeren & Henriquez, 2013; Dobbs, et. al. 2012]. Local governments have greater flexibility to create effective policy solutions and are more likely to pursue innovative and creative strategies than their national counterparts [Timmeren & Henriquez, 2013]. This makes urban regions key to finding effective solutions for the consequences of climate change.

Sustainability has emerged as a necessary condition if urbanism is to remain resilient for human life in the future [Timmeren, 2007; Beatley,2000; Calthorpe, 2010]. It represents a transformation of the built environment and the way in which it operates, and should incorporate a new policy focus that embraces compact city concepts with green economy concepts and objectives [Lehmann, 2010]. While meeting heat demand is easier in cities, the largest challenge is finding ways to meet general energy demand at higher building densities [Timmeren & Henriquez, 2013]. The preference for fossil fuels come from its lower price (at first) and larger energy density per mass unit compared to renewable energy technologies. To meet energy demands within todays urbanizing contexts it is required to find more intelligent and integrated solutions. Fortunately, the potential information and communication technologies (ICT) resulting in 'smart' grids, district heating and cooling, smart water management, sensors, monitoring. The revolutions of big data, empowerment of individuals and self-organized

-Figure 1- Resilient Aerotropolis uses three drivers as a base



communities and companies will foster urban environments of the future. Data tied to geography becomes important information, giving communities greater options for faster, more efficient decision making and systems. All things that relate to technological advances and integration thereof, has yet to reach its limit. As Jeremy Rifkin describes in his book, the third industrial revolution [2011] and also underlined during his speech at last years' TVVL Smart Cities event on 4 November 2015, we are on the brink of a new era. New economic models, which take advantage of technological integration and progress, are in still only embryotic stages and have yet to become adolescent, let alone fully mature.
It is no longer a matter of asking **if** we can adapt, but of **when** we do and how we go about implementing that change. We are only dipping our toes in the endless pool of possibilities tech has in store. This is not because our engineers are incapable, not because technology is incompatible, not because policy makers are dismissive, but because there is a lack of holistic understanding and perhaps a short term horizon.

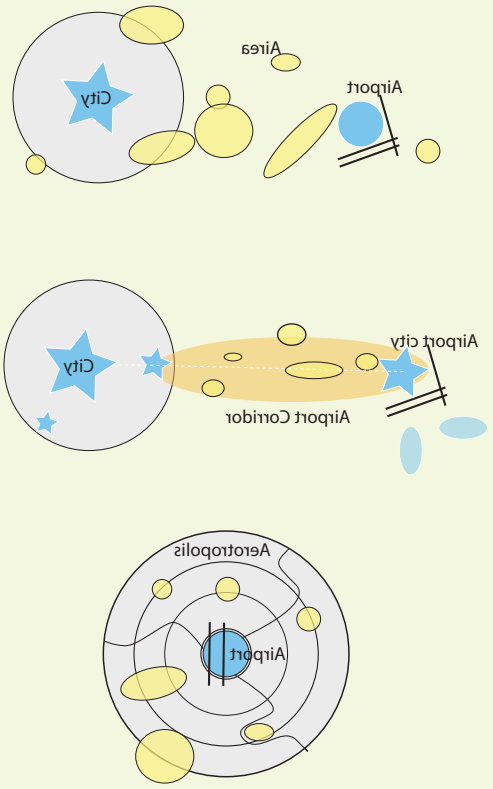
CONTEXT

According to Rifkin [2011] urban development and the role of cities/regions, will change.
In fact as Saskia Sassen [2007] has claimed, national governments will no longer have the monopoly on (political) power. In a world where over 75% of a 9 billion population live in urban areas in 2050, it will be those urban areas, agglomerations of cities, which will wield world politics and economics. This implies that the urban and regional scale is quintessential in pursuit of resilient cites and societies.
Our economic centers are increasingly defined by global connectivity. Historically urban development thrived at locations favorably situated at the merging point of two or more diverse regions with complementary resources and skills [Mumford 1956]. Air travel has eliminated that physical restriction. Urban areas have become the milieu of the global economy, its control centers and its workforce [Timmeren et al., 2015]. Consequently, the typical global city is much more complex as a growing number of spatial and virtual connections extend across traditional political boundaries. In theory any location on earth is reachable within approximately 24 to 36 hours, as long as there is an airport.
As such airports have become important entities that drive development [Nunn 2005, Green 2007, Janic 2008, Freestone 2009]. Strategically located, airports offer high levels of connectivity, speed and agility [Kasarda 2006] for companies operating in the global economy. Airport companies try to leverage their unique position within the global network to attract passengers [Pels et al. 2001] airlines and in their wake companies (business) to their vicinities. The jet-age has, as some would argue, smashed our world flat [Friedman 2007]. Others would argue the contrary describing that the concentration of wealth is accumulating in certain specific locations across the global that are strongly connected [Wall 2009, Piketty 2013]. In addition to being better suited to addressing sustainability, UN-Habitat identifies cities as a remedy to global crises, such as the financial and democratic crises that characterize conflicts plaguing all regions of the globe.
While the standpoints differ substantially the driver is the quite similar: national economies have made way for a global economy which is the result of extensive globalization and specialization. This phenomenon is super charging the impetus to build airports as key assets of city and regions. This is seen in emerging economies i.e. China has plans to develop 100 new airport (cities) in the next two decades, India trailing with some 50. And existing airports are also leveraging their assets to develop regions.
At the dawning of the jet-age in the seventies airports were often placed far outside the city centers.
Those airports often have large areas of land surrounding them that present significant value in the globalized connected world. This land has become a key asset to the regions it is located in, unlocking two potentials that serve the region. Firstly, it offers the potential to unlock additional income of so called non-aeronautical revenue for the airports. This is important because of the emergence of low-cost airlines and increased volatility of the airlines network, [Neufville et al. 2013] driven through open skies treatise and airline alliances. Airports strive to increase this non-aeronautical revenue stream in order to maintain operations and increase profitability. Secondly, it provides the potential for increased socio-economic prosperity for the greater region through the creation of new employment and diversification of region economies. As Maurits Schaafsma from Schiphol airport said (2011): "Airports tend to leave the city, but the city 'follows' the airport, and the airport becomes a 'city'."

FOREIGN DIRECT INVESTMENT

Foreign Direct Investment (FDI) is the primary mechanism of regional economies [Grimwade, 2000]. FDI (generally) brings capital, technology and knowledge to a region [WIR 2014]. As such FDI provides the potential for increased socio-economic prosperity through the creation of new employment and diversification of specialized regional economies. Alfred Marshall [1980, 1919] was "one of the first to economists to note the tendency for firms to concentrate in space, sharing common factors of production (i.e. infrastructure specialized labor pools and access to capital)." Sharing these externalities through the agglomeration of firms leads to an upward spiral. It drives down unit production costs leading to economies of scale. Thus driving further growth and specialization in the agglomeration. According to Marshall the emerging industrial district based on diversified and flexible network highly specialized firms allows for a rapid adaptability of changing market demands. This creates a self-reinforcing feedback loop of growth and specialization [Alexander 1954] [Jacobs 1970].
Most regional development policies agree that airports bring economic benefits. Economic development and the correlating socio-economic development are intertwined with the theories of aerotropolis and the airport region. To strengthen investment inflows, 'airport-corridors' [Schaafsma et al., 2008] 'airport cities', [Schlaak, 2010] and 'Aerotropoli' [Kasarda, 2006] have been developed. These three concepts all accept the airport as an

-Figure 2- GIS map of FDI from worldwide cities (white) into aerotropoli (red)



-Figure 3- Airea, airport corridor and Aerotropolis

important part of the city/urban region. Airports are key determinants in the attraction of FDI to urban regions [Burger et al. 2013]. Therefore, high quality airports and related infrastructures are required to raise the competitiveness of regions. It is not merely the presence of an airport that is important to attract investment. FDI seeks out locations with the right social, spatial, economic and political conditions [Kitson et al. 2004]. It is therefore increasingly important for urban regions to understand their investment attractiveness. Knowing which factors attract FDI is essential to planning competitive regions [Gospodini, 2006].

SPATIAL PLANNING

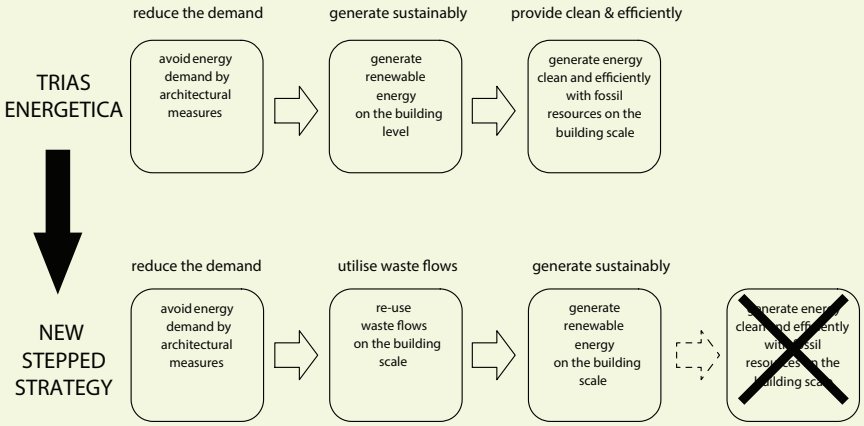
The diversified economy of highly specialized firms has led to a rapid the urbanization which has resulted in new forms of urbanism. This is the spatial expression of trade and transportation of our globalized economy.
Over the past few decades, airports have grown to airport corridors [Schaafsma et al., 2008] and airport cities, Airea [Schlaak, 2010] and, even more significant in size and importance, 'aerotropoli' [Kassarda, 2000]. Aerotropoli regions in which (hub-) airports (re-)route passengers and cargo, information, and capital connecting adjacent regions to the world economy. However some authors criticize the latter models [Freestone & Baker, 2011; Charles et al., 2007] and airport region planning itself [Donnet & Keast, 2010].
Schiphol Airport has coined the term "Airport City", which on the one hand serves for real estate marketing and brand building, and on the other hand has established the notion of the airport as a (generic) city [Koolhaas, 1995]. Recently, Schaafsma et. al. [2010] have put forward the "Airport Corridor" as a refinement of this model beyond the fence. The model of the airport as a city has been contested in academic debate, with the suggestion of Schiphol being an "Edge City" instead [Bontje et. al. 2005]. More importantly, the "Airport City" model is tailored to the situation of Schiphol Airport, and therefore difficult to apply to other airports. On a more fundamental level, there have been attempts to classify the effects of airports on urban development along economic categories [Prins 2008].
A similar economic-functional view on airports and cities also lies at the heart of the second conceptual model, the "Aerotropolis" model by John D. Kasarda [cf. 2010]. It is based on a monocentric, functionalist urban model and roughly describes an optimal industrial-logistics cluster embedded in both local and global supply chains.
The "Airport City" is basically a business case geared towards airport operators, while the "Aerotropolis" fits best in non-democratic societies with command-and-control structures. Both are, however, currently in use as blueprints for airport and urban development, notably in Asia. Because of their functionalist rigor, is doubtful whether these models will produce environments that are flexible and adaptable enough to be robust and resilient in the long term. Furthermore, there are more areas of actual and potential reciprocity between airport and metropolitan region, notably in social, economic and ecological perspective. These models neglect the great potential that lies in a more balanced approach to integrate economic, social, and ecological demands in an adequate governance structure [Michaeli et.al. (2009)].
One must aim to understand the spatial characteristics (typologies, morphologies, network layout) timing, location and factors behind the spatial transformation, and its different development stages.
An Understanding of the spatial typologies, time-lags, the correlation of connectivity within, from and towards the region, and type of FDI attracted, may allow for a classification of airport region types or their generic characteristics. Airport Regions overall are not generic thus spatial planning and urban morphology of built (infra) structures is a differentiator.

SUSTAINABLE INFRASTRUCTURE

Today, societies are recognizing their profound impact on the global environment. As explained by various researchers, humans are depleting the planet's resources and affecting the physical environment (Meadows et al. 1972; Meadows et al. 1992). As a response, policies are created to enable entities (companies and governments) to incorporate sustainability measures, reflected in corporate social responsibility (CSR) strategies, and farther reaching regional goals. This trend is in part "sales talk", however current sustainable development can yield benefits and should not be abandoned.
Since the end of the 1980's sustainable approaches to urban areas have followed the well-known three-stepped strategy:
1.reduce consumption;
2.use renewable sources;
3.supply the remaining demand cleanly and efficiently.

This strategy towards energy use is known as the Trias Energetica [Lysen, 1996]. It forms the guideline for a logical, environmentally conscious approach but in the twenty years that it has been in use it has not led to the required sustainability. In particular, the degree of penetration of renewable energy sources, i.e. step two, is minimal. The New Stepped Strategy, developed by the TU Delft adds an important intermediate step between the reduction in consumption and the generation of energy from sustainable sources, and incorporates a waste products strategy (partially inspired by the Cradle-to-Cradle philosophy):
1.reduce consumption (using intelligent and bioclimatic design);
2.reuse waste energy streams;
3.use renewable energy sources and ensure that waste is reused as food;
4.and deleting the final step (4. supply the remaining demand cleanly and efficiently).

The TU Delft with partners converted the New Stepped Strategy into a strategy which can be used to redevelop a spatial area entirely on the basis of existing energy potentials, the so called REAP approach (Rotterdam Energy Approach and Planning [Tillie et al., 2009]). The REAP approach is based on a sequential walk through the different scale-levels (figure 4). It was tested in a southern district of Rotterdam ('Hart van Zuid') and further



-Figure 4- Trias Energetica vs New Stepped Strategy (Source: Tillie, N., et.al. [2009])

elaborated and applied to the city harbour area of 'Merwe Vierhavens', during the REAP2 [Dobbelsteen et al., 2011].

These and other studies have thus shown that through appropriate planning, urban zones can be developed sustainably (Dobbelsteen et al. 2014) with the potential to reach carbon and energy neutrality. This is greatest when urban entities collaborate (Tillie et al. 2009; Kürschner et al. 2011). Infrastructures and smart utility networks are quintessential in the pursuit of a resilient built environments, especially in and around arguably the most complex of these, the aerotropoli. Fortunately aerotropolis regions offer a unique opportunity: their core, the airport and immediate surrounding areas, are controlled by airports operators or airport authorities. Their economic power and societal importance result in the ability and responsibility to attain a leadership role. As such the airports can and should function as the heart of the smart utility networks. From the core the smart utility infrastructure can be developed outward, incorporating entire regions and rendering them sustainable, competitive and resilient.

The principle behind Smart Utility Networks is simple. What is excess or even waste for one participant could be a welcome resource or raw material for another participant within the same network. Within a Smart Utility Network, any member can be both a supplier and a buyer, of various resources including electricity and thermal energy, water, gases and even refuse (waste material), see Figure 5. The networks' flexibility and adaptability in principle render them future proof.

Smart Utility Networks strive for synergies within buildings and local areas that result in a secure, reliable and cost efficient energy supply. Sustainability is guaranteed through the storage and re-use of (natural) resources and the advantage of renewables. These smart utility networks can be applied at any conceivable level or scale. From a network which involves only the exchange of heat to a completely integrated smart network which encompasses all utilities and natural resources. This also relates to the building scale, i.e. a hospital that aspires to be energy neutral, to entire districts and/or cities in which industries, offices, residential and leisure facilities are all connected to a single intelligent network.

An underlying hypothesis is that in the current market smart utility networks (SUN), that enable a circular flow of resources throughout the region, by allowing buildings and local areas to collaborate on an urban or district scale, increase the attractiveness for FDI. The reasoning behind this hypothesis is that Smart utility Networks would make locating into specific airport regions more attractive for firms both financially and from an environmental perspective, which coincides with the current sustainability trend in marketing of firms. Locating a headquarters in a "green district" might be a significant in fact a deciding factor for site selection and hence significant to differentiate regions. For the airports the increased non-aeronautical revenue and clear leadership role in resilient urban development will further strengthen their own competitive position and societal importance.

APPROACH

We believe by combining the three drivers described above, society will be able to leverage the dynamics of our global economy to create resilient urban regions. As such, the authors are currently working towards a research that specifically aims at an empirical grounding of the underlying dynamics of economic geography, spatial planning and sustainable infrastructure in relation to the airport region. If indeed the hypothesis is proven it follows that the invisible structure of smart utility networks wields significant power. Smart utility networks become one of the drivers for the functional planning and mix of urban regions, and that would have far going implications of building design, urban design, regional design and policy.

Using these three drivers as a base allows engineers and policy makers to leverage technology. They integrate their perspectives into a holistic understanding of long term goals. With smart utility networks as a vehicle these regions are able to successfully develop into resilient urban areas for the future of Homo Urbanus.

REFS

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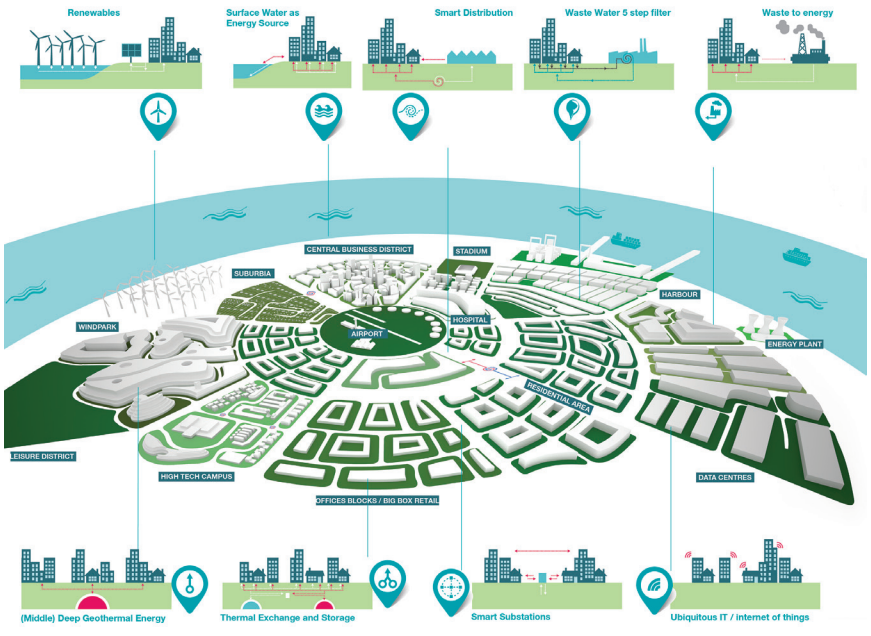

-Figure 5- Airport city and environmental infrastructure potentials (source: Deerns)