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Cities of the Future: Synergies Between Smart Energy and Greenways

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Introduction

We are well on the way to becoming an urban world. According to the United Nations *World Economic and Social Survey* (UN, 2013), at least half the world's population has been living in cities since 2007, a figure that is projected to rise to more than 70 percent by 2050. This poses unprecedented challenges in light of increasing pressures on world energy reserves, the uncertain and potentially devastating effects of climate change, other forms of environmental degradation, and a range of problems related to urban living such as overcrowding in city centers and sprawl in suburban areas and beyond.

The planning community should not abandon hope; instead, increasing urbanization makes it easier to solve such problems. As Steve Raynor (2012) has observed, increasing urbanization represents an opportunity to utilize the population and infrastructure density characteristics of urban form to create solutions that can mitigate climate change, replenish or renew resources, and improve the environment. Perhaps more importantly, it should be possible to work at the intersections of policy, energy technology research and development, human and consumer behavior, and landscape and greenway planning to incorporate these components into the future design of urban form to improve human health and well-being, create greener urban areas, and build and maintain a sense of community among urban residents.

Two areas where planners can tackle important issues can be found at the intersection of energy and nature. With continued innovations in technologies, whether personal or large scale, energy technology, in particular "smart energy" solutions, must be included not only in thinking about how cities should be shaped in the future but also in proactively planning to meet the demands of our technological era. Additionally, solutions integral to planning should seek to create what some call "cities of the future," cities whose energy infrastructures achieve a range of outcomes from sustainability to regeneration as well as the resilience of the urban environment. This makes smart energy planning a natural companion to urban greenway planning, since both seek to contribute to the sustainable, regenerative, and resilient urban form that must mark cities of the future. Planners must explore the potential for finding synergies between smart energy and greenways that would do more than simply include them under the same smart urban planning umbrella.

Smart Energy: Towards a Sustainable Future

With a wide range of new techologies emerging to facilitate the integration of renewable sources of energy into existing energy grids as well as to pioneer new models of energy generation, storage, and distribution, the pieces needed to create cities of the future are falling into place. Existing major regional energy grids across the U.S. are beginning to develop interconnections with solar, wind, and other sustainable or renewable resources to supplement conventional energy sources. The current challenge with renewables lies in smoothing supply due to the inconsistency of weather in many parts of the country that can cause spikes and dips, but in the near future improved battery-based and other storage techologies should make it possible to harness renewables in ever-increasing magnitudes. „Smart grids" will implement sophisticated information technology (IT) systems to coordinate the process of smoothing loads and distributing power where and when it is needed; this is one of many benefits it can bring to the conventional electricity grid.

While cities of the future will depend in large part on this process of integrating renewables into large-scale systems, smaller-scale systems across the world are already demonstrating how smart energy may help us solve some very difficult problems. These smaller-scale solutions range from district- and neighborhood-level microgrids to freestanding systems at the individual household level. According to the Rocky Mountain Institute (2016), a phenomenon known as „grid defection," whereby customers find it cheaper to deploy self-contained systems—comprising solar, i.e., photovoltaic (PV) panels and battery storage—than to buy their electricity from utility companies managing large-scale grids may be the wave of the future.

The same organization published a set of case studies of ten small island and other remote communities that have successfully implemented microgrids using distributed renewable energy sources such as solar, wind, hydro, and biodiesel with energy storage to distribute power to residents (Bunker, et al., 2015). These microgrids are being utilized in Europe, the United States, Australia, the Caribbean, and even Antarctica. The technology is scalable and could be integrated into smart cities of the future by interconnecting microgrids or connecting them to larger regional grids.

The key is to incorporate energy technologies and models into the planning process to achieve sustainable and resilient urban form. The solar-plus-storage technology has the potential to operate well beyond the individual household level; creating synergies with greenway and landscape planning in utilizing solar-plus-storage at the microgrid level. The main barrier to this technology is the cost of lithium-ion (Li-ion) batteries (Rowlands-Rees, Izadi-Najafabadi, & Orlandi, 2015), as it is well known that the cost of solar installations, whether in roof-top or freestanding on-the-ground configurations, has been dropping steadily and is now well within the budgets of some households and small communities, in large part due to tax incentives in the U.S.

The cost of Li-ion batteries is dropping (see Figure 1) and its density is increasing incrementally and will continue to do so (Crabtree, Kocs, & Trahey, 2015). The most important development that could drive the price into small-scale affordability would be the expansion of the electric vehicle (EV) market (Crabtree, Kocs, & Aláan, 2014). That would enable the storage battery industry to scale up production to serve multiple markets, including the energy grid market. Being able to store and distribute energy generated by solar panels or wind turbines is the key to making this technology effective. Not coincidentally, this particular synergy between the EV industry and solar-plus-storage technology features two important components of cities of the future, insofar as automobile traffic in urban areas generates high levels of carbon emissions. Expanding the EV market (including electric bicycles) can therefore not only facilitate the use of smart energy to further reduce a city's carbon footprint, it can also make urban streets and highways greener.

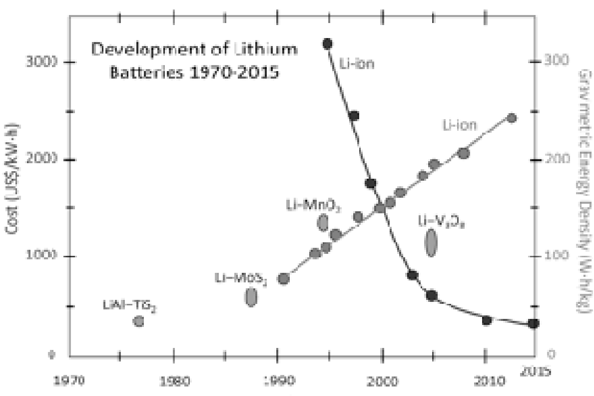

Figure 1. Cost Trend for Lithium-Ion Batteries (Crabtree, et al., 2015, p. 1073)

The smart city of the future will also be resilient. From the energy standpoint, resilience is simply the „ability of the electricity system to resist failure and rapidly recover from breakdown" (Bunker et al., 2015, p. 26). The UN offers a broader definition of resilience: „the ability of a system, community, or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including the preservation and restoration of its essential basic structures and functions" (UN, 2010, p. 13). More broadly, however, the resilient city of the future will be able to react effectively to ecological problems, manage hazards and disasters, cope with shocks to the economies of urban developments and regions, and promote resilience through effective planning and governance (de Jong, et al., 2015). Achieving these objectives requires adaptability, smart spatial planning, and a sustainable and resilient urban form „consisting of compactness, density, mixed land use, diversity, passive solar design, greening, and renewal" (Jabareen, 2013). Indeed, building resiliency into urban form presents another

Greenway Planning & Smart Energy: Towards Sustainable Urban Form

It is easy to make the case for including smart energy and greenway/landscape planning under the banner of sustainable urban form. At its most basic level sustainability means meeting the „development needs" of urban residents „without imposing unsustainable demands on local or global natural resources or systems" (Satterthwaite, 1992, p. 3). This basic definition has been elaborated over the past two decades to include a far more robust conception of ways in which urban form can not only mitigate environmental harm but even regenerate environmental systems while fostering community among a city's residents. Such an approach moves us closer to our present-day conception of the smart city of the future.

Figure 2 represents the UN's framework for sustainable urban form, identifying what it calls the „four pillars" of sustainable development. These are the four broad areas in which investment will be needed to achieve the goal of urban sustainability. We can see roles for smart energy and greenways under multiple pillars. Clearly smart energy should play a role under social development in green housing, green public transportation, and green energy access. Smart energy will be essential to economic development for producing and distributing renewable energy as well as technology and innovation and, under environmental management, in achieving energy efficiency, better air quality, and adapting to and mitigating the effects of climate change.

Greenway and landscape planning will also play multiple roles in achieving sustainable urban form in cities of the future by contributing to social development through expanding recreation areas and to economic development through creating employment opportunities. It could also be involved in producing and distributing renewable energy. It seems obvious that greenways and related landscaping forms can contribute under environmental management to improving forests and soils, managing water-related issues, improving air quality, and contributing to climate change mitigation.

Figure 2. Pillars for Achieving Sustainability of Cities (UN, 2013, p. 62)

That both smart energy and greenways can play vital roles in achieving sustainable urban form will not surprise those of us who strive in various ways to create cities of the future, but merely including both in broader planning processes does not mean that they can be combined into synergistic relationships that contribute uniquely to achieving the goals of sustainability. There are several such relationships involving contributions that the two sides of this equation—smart energy and greenways—can make to one another as well as to sustainable and resilient urban form.

Seeking Synergies between Smart Energy and Greenways in Cities of the Future

Smart systems that exploit renewable resources such as solar or wind and utilize storage and distributed energy grids share with many greenway planning proposals a networked structure. Smart energy networks and greenway networks can co-exist in a mutually beneficial relationship.

Anthony Walmsley (2006), in an article touching on smart conservation and smart growth in application to New Urbanist and Mixed-Use Pocket developments, argues that greenway planning should be included in the urban planning and development process from the outset. While acknowledging the „predominantly ecological" purpose of green corridors (p. 264), Walmsley argues that, in the context of the broader goal of smart growth (creating what can be considered cities of the future), „green infrastructure has to be planned and designed; it requires the same kinds of considered decision-making and prior investment [as development planning], and it is best undertaken in advance of development" (p. 265). The idea is to balance smart conservation with smart growth, and that's where smart energy enters the picture.

David Cartes and colleagues (Cartes et al., 2007), in a paper written for an Institute of Electrical and Electronics Engineers (IEEE) conference, make the case for what they call integrated community-based energy systems that operate at a scale that fits the sort of New Urbanism development that Walmsley espouses. They envision community-based systems that include considerable consumer participation in the planning stages and neighborhood- or wider-scale systems that incorporate either home-based smart energy systems or neighborhood-scale central systems connecting multiple homes. At the individual household scale, individual homes would be outfitted with their own high-efficiency heating and cooling systems, PV arrays to collect solar energy, and battery stacks to store energy for home use. Scaling up such an integrated energy system to neighborhood scale would mean connecting homes in the area to a centralized (but still highly localized) energy center. Such an energy center could incorporate a diversity of energy generation and storage technologies depending on its location.

Neighborhood-scale energy centers could include generators that utilize stored energy to maintain power during outages (thereby increasing resiliency) or, with interconnections to regional energy grids, redistribute excess power to wider communities. As the authors note, such a central facility „could be architecturally treated to blend in with the other structures in the subdivision" (Cartes et al., 2007, p. 3). Here, there is an opportunity to integrate greenway planning into the smart energy model, as greenways and other green areas could be used to not only site such energy generation and storage facilities, using plantings and landscaping to screen the facilities from view, but also to find ways to integrate them into the local urban landscape.

Indeed, Cartes and colleagues (2007) note that utilizing integrated energy systems in conjunction with what they term green development (also known as smart development) could bring „lower operating costs for residents, increased comfort, higher perceived value, reduced sprawl, and protection of the natural environment." They then argue that a range of green development options, including greenbelts and greenways, „need to be considered in the overall initial site development for integrated energy systems" (p. 5).

Greenways that serve the purpose of screening or helping to integrate smart energy installations on a larger scale could be mapped onto energy distribution networks or plantings could be use to better integrate small solar installations to power greenway lighting or signage. Conceiveably, strategic planting along greenways could screen nearby EV charging stations for cars parked at the periphery or electric bicycles to be used on paths or trails integrated into the greenways. Although using greenway plantings to screen smart energy facilities would not in itself justify building greenways, it would require the sort of integrated planning approach Walmsley calls for. Greenways can be screens for energy technologies as well as spaces for integration of energy generation, distribution, storage and technology in ways that have not been considered before, and given the prevalence of greenway spaces and planning in urban areas, there is an opportunity here to combine efforts to achieve more vibrant, innovative and resilient cities of the future.

An integral synergy between greenways and smart cities is one that increases resiliency. In addition to adding green, carbon-absorbing vegetation to urban landscapes, greenways can been used to control or mitigate the effects of flooding and other hydrological phenomena when installed along riparian corridors in urban or suburban areas by „stabilising surface and groundwater flows" during recharge and discharge and through „nutrient and sediment buffering" (Ahern, 2003, p. 44). In this way greenways and smart energy can both contribute to making the city of the future a more resilient city.

Greenways offer several other benefits that fit the model of the smart city of the future, including connecting communities, mitigating the effects of climate change and improving air quality in urban areas. Indeed, the UN recognizes increasing „green areas" as among the requirements for building sustainable cities, along with investing in renewable energy sources (UN, 2013, p. 6). Thus smart energy and greenway planning will become increasingly integrated in the city of the future.

Planning the city of the future will no doubt involve many bold initiatives that have yet to emerge. Exploring the potential to use greenways not only to mitigate or repair environmental damage but also to contribute directly to the smart energy mix should be a high priority. One renewable energy source that could be integrated, perhaps on a large scale, into greenway planning is biomass energy, which is „energy obtained from plants and plant-derived materials" (NREL, 2014). Biomass can be used to produce energy in the form of biofuels to replace petroleum-based fuels for transportation (thus reducing automobile-generated greenhouse gas emissions) and to generate electricity. It can also be used for „bioproducts," created by converting biomass into plastic substitutes. These could all be natural contributions to the city of the future.

Biomass could easily be incorporated into smart integrated energy systems in place of other renewable energy sources. An urban area with extensive green infrastructure, including greenways and greenbelts, might have considerable potential to integrate biomass plantings among the more permanent plantings that provide greenways with many of the environmental and social benefits they bring. Based on the NREL's explanation of biomass production, greenway planners might very well be able to incorporate certain species of rapidly growing trees and grasses (such as switchgrass) into green corridors and other green infrastructure. That would represent the ultimate synergy between greenways and smart energy, with the former fueling the latter.

The rapid pace of smart technology development will likely create many other opportunities to incorporate smart energy and green infrastructure into the city of the future. Planning for synergies will take best advantage of the benefits of both. Integration is critical to successfully planning cities of the future.

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