



# Sustainable Infrastructure in Shrinking Cities

OPTIONS FOR THE FUTURE



John Hoornbeek, Ph.D., Director  
Center for Public Administration and Public Policy

Terry Schwarz, Senior Planner  
Cleveland Urban Design Collaborative

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*Sustainable Infrastructure in Shrinking Cities: Options for the Future* is a research project completed by the Center for Public Administration and Public Policy and the Cleveland Urban Design Collaborative at Kent State University. The report includes a synopsis of recent literature regarding the management of water, sewer, transportation, and energy infrastructure in shrinking cities. It presents findings from a series of interviews with infrastructure management professionals, most of whom are from Northeast Ohio. The work is focused on the City of Cleveland, but the findings should be applicable to other cities in similar circumstances.

The literature search revealed a deficit in terms of research directed specifically toward the unique challenges and opportunities for managing infrastructure in a context of population decline. However, the sources we did find provided the basis for interviews with some of the people responsible for managing roads, bridges, sewers, and power grids in Northeast Ohio. They in turn provided us with real world insights into the opportunities and limitations for reconfiguring infrastructure networks in response to changing demographics and reduced demand.

We found that decommissioning infrastructure is not a high priority in Cleveland for a variety of reasons. First, engineers and public works professionals are trained to maintain and expand infrastructure networks—the idea of removing infrastructure is totally contrary to business as usual. Most of the infrastructure management professionals interviewed for this study thought that it is better to incur the costs of maintaining entire infrastructure networks at some minimal level, rather than to remove infrastructure that may need to be reinstated at some point in the future.

We found no evidence that the maintenance costs saved by downsizing infrastructure would outweigh the opportunity costs of removing something that might prove useful in the future. The issue is further complicated by the expense and physical difficulties associated with

decommissioning infrastructure. There are significant capital costs involved in removing roads, sewers, and water lines. The people we interviewed were understandably hesitant to spend scarce resources now to achieve a possible (but nebulous) maintenance cost savings in the future. Compounding their resistance is the fact that the future is unknown. The City of Cleveland has significant assets that point toward long-term growth and recovery. Surplus capacity—particularly in water, energy, and transportation infrastructure—is a competitive advantage that can be used to attract businesses and economic development to the region. Eliminating this surplus now could prove counter-productive over the long term.

There are also physical constraints to downsizing infrastructure networks. Infrastructure operates on a fixed grid and it is difficult to remove components in depopulated areas without impacting the whole system. Water, sewers, roads, and power lines need to extend through depopulated areas in order to get to areas of the city and region where concentrations of people still live and work. And when cities are dealing with old infrastructure, redundancy is a benefit. When bridges fail, water and sewer lines break, and pumping stations need to come offline for maintenance, redundant aspects of an infrastructure network provide a back-up that enables a city to continue to meet the needs of residents and businesses in these emergency situations.

Rather than eliminating infrastructure, shrinking cities might focus instead on optimizing the use and functioning of existing infrastructure in ways that reduce current costs while preserving opportunities for future growth and development. Asset management strategies, better coordination across infrastructures, the use of SMART technologies, the harnessing of vacant lands for renewable energy production and stormwater management, and identifying and publicizing the costs of sprawling development patterns are all among the ideas described in this report for optimizing infrastructure in shrinking cities. We recommend further research in these areas.

## INTRODUCTION

Urban growth goes hand in hand with infrastructure development. As cities grow, the need for infrastructure grows as well. But is the inverse also true? Do shrinking cities have opportunities to scale back infrastructure in an effort to reduce maintenance and operating costs?

This report outlines the results of a preliminary investigation that evaluates opportunities and constraints related to improving the efficiency of infrastructure networks in cities with declining populations. We also begin to weigh the long-term benefits and future cost-savings against the more immediate costs of downsizing existing infrastructure networks. The report specifically addresses water and wastewater infrastructure, transportation networks, and energy infrastructure as well as potential connections among these infrastructures that may affect both long term costs and the quality of services provided. The report also addresses the application of management and technical approaches that are common to the infrastructure management field in situations of both growth and decline.

We find that in many cases, infrastructure cannot be downsized easily because an acceptable level of service needs to be maintained for the remaining population and the long term potential for growth needs to be taken into account. Also, many components of infrastructure networks are immobile and therefore difficult to subdivide into smaller systems. Costs tend to remain fixed and sometimes become higher as demand is reduced.<sup>1</sup> At the same time, we identify potential strategies for sustainable infrastructure management that may be applied productively in shrinking cities. These strategies may aid officials and public works staff in making better long term decisions about maintaining infrastructure networks that were originally designed to serve much larger populations.

In the end, however, there is a need to move beyond the preliminary conclusions reached in this study to develop a more complete understanding of the promising infrastructure management strategies identified in this report and their application to the circumstances of particular cities and urban areas. For this reason, we also identify areas of inquiry that may be beneficial for further research and development.

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<sup>1</sup> G. Schiller and S. Siedentop, "Preserving cost-Efficient Infrastructure Supply in Shrinking Cities," Leibniz Institute of Ecological and Regional Development (IOER), Dresden, Germany, 2006.

## BACKGROUND

Many older industrial cities in Ohio and throughout the Great Lakes region have lost a substantial percentage of their population and continue to lose residents. This phenomenon is also occurring elsewhere in the United States and on an international scale, particularly in Eastern Europe where population decline has been significant. There is considerable research underway to address the unique challenges of shrinking cities. Downsizing infrastructure is frequently cited as a possible means for reducing costs and managing scarce resources in response to population decline, but the potential for downsizing infrastructure needs to be analyzed in greater detail.

It is with this recognition the Northeast Ohio Research Consortium (NEORC) provided funding support to Kent State University's Center for Public Administration and Public Policy and Cleveland Urban Design Collaborative to carry out a preliminary investigation of current knowledge in this area and identify potentially promising areas for further research and development.

While cities need to provide good service to the residents who remain in depopulating cities, they also need to anticipate future changes in population and demand. Increasingly, cities also need to identify strategies that are most likely to result in cost savings, efficient service delivery, and improved functioning of urban systems over time. This research is intended to guide current infrastructure planning and identify issues for more in-depth exploration.



## RESEARCH APPROACH

The research team collected and assessed a range of potential strategies for sustainable infrastructure and the mechanisms available to manage and reconfigure infrastructure in cities where population is declining. The research uses Cleveland, Ohio as a sample case, but the options studied should be transferable to other cities experiencing population loss. Transferability is important because all major cities in Ohio (except for Columbus) have been losing population over the last 50 years, and population losses have occurred in many other cities in the U.S. and around the world as well.

This research effort has three major components:

- 1. Literature Search** The research team collected written information regarding the general area of sustainable infrastructure and the more specific topic of maintaining infrastructure services in areas with declining populations. The literature search focused on water and wastewater infrastructure, transportation, and energy infrastructure. We also participated in a major conference on sustainable water infrastructure sponsored by U.S. Environmental Protection Agency in St. Louis, Missouri at the beginning of the project effort in November, 2007.
- 2. Interviews** We conducted interviews with key personnel responsible for managing infrastructure services in Cleveland, the northeast Ohio region, and selected other areas. The interviews helped us understand how urban infrastructure is managed, particularly in areas of low density and population decline. The interviews established the parameters of current infrastructure management practices in Cleveland and, to some extent, the surrounding region. We also inquired about options for infrastructure management that may be considered in the future.
- 3. Report** We then compiled the information collected in the first two stages and prepared this report, which outlines the options we identified for infrastructure management in cities with shrinking populations. The report evaluates alternative management strategies that could yield more sustainable infrastructure practices in the future. Accompanying the options are brief discussions of potential obstacles and benefits associated with their implementation. Given time and resource constraints, the report focuses on identifying and describing options, rather than on evaluating their applicability to particular situations. More in-depth analyses of particular topics and cities may be conducted at a later time as warranted.

## LITERATURE REVIEW | INTERVIEW FINDINGS

Much of the recent shrinking cities research focuses primarily on vacant buildings and land. The question of sustainable infrastructure in the context of population decline has not been systematically explored, particularly in a US context. We identified several Eastern European sources, where the shrinking cities phenomenon has been a major research topic for the last several years. We located articles more broadly related to the costs of infrastructure management and in some cases we were able to glean information from these sources about how costs and management practices are different in declining cities than in growing ones.

Thomas Dye's article, "Government Finances in Declining Central Cities," provided a good starting point for this work. The article looks at the per capita costs to maintain the infrastructure in cities. He notes that the infrastructure grid is fixed and difficult to adapt to circumstances of population decline. With a declining population, a city has a smaller base of revenue. Infrastructure services often cost more in a declining city with aging infrastructure and there are fewer people to share this cost, resulting in a higher per capita cost."<sup>2</sup>

In conjunction with the literature review, we interviewed ten people who are knowledgeable regarding particular areas of infrastructure management. In many respects these interviews re-enforced the central point of Dye's article. Infrastructure costs tend to be fixed, so reductions in demand for infrastructure services typically do not reduce costs. At the same time, because infrastructure decisions have been driven largely by short-term considerations associated with specific development opportunities, they have often failed to account for considerations of long term sustainability. Individual infrastructure systems such as transportation, water and wastewater operations, and energy production and dissemination respond to specific opportunities, but often do not account well for the inter-relatedness of their decisions.

These interviews also highlighted a host of other considerations that need to be taken into account in evaluating infrastructure management options in shrinking cities. These include the value of redundancy in infrastructure networks, the costs and risks of decommissioning existing infrastructure, and the need to think of infrastructure as a series of inter-related support systems that should be tied together to serve metropolitan areas in a sustainable and cost-effective fashion.

Because the literature review and interviews yielded mutually re-enforcing insights and conclusions, we present our findings from these endeavors jointly in the subsections that follow.

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<sup>2</sup> Thomas R. Dye, "Government Finances in Declining Central Cities." *Publius* 14:2 (1984): 21-29.

## Sustainable Infrastructure – General Principles

The literature search identified recent research in the area of sustainable infrastructure as it applies to both shrinking and growing cities. For the purposes of this work, we analyzed current thinking on sustainable infrastructure from the perspective of cities that are experiencing substantial and on-going population loss.

In the context of infrastructure studies, this is an unusual perspective. There is a clear tendency to focus on expanding capacity, perhaps driven by the growth paradigm that guides land use and development decisions in most American cities. However, there are those who believe that depopulation and its effects on infrastructure is an important topic for consideration in studies of long term sustainability. For example, in B.J. Wattenberg's book, *Fewer: How the New Demography of Depopulation will Shape Our Future*, global population decline is anticipated as a possible outcome of overtaxing the planet's resources.<sup>3</sup> This idea is further articulated in business analyst Tim Prosser's weblog:

*When population declines to a sustainable level of perhaps two billion or less, half or more of all structures will be unneeded. While some roads, airports, and railways may be abandoned, most will still have traffic, but just a lot less of it than today depending on how much of our current mobility is retained. Similarly, high volume electrical power and pipeline infrastructures will be used, but probably under far lower demand than today. Maintenance costs for major infrastructure elements will not be able to decline as much as the population, suggesting costs will be generally higher for travel and transportation services.<sup>4</sup>*

In many shrinking cities, this prediction is becoming a reality. As such, these places could serve as laboratories for testing methods of adapting infrastructure networks in response to population loss. The most effective methods could be developed and refined now, reducing the risk for major disruptions in cities which subsequently develop major population loss problems.

There are clear correlations between land use decisions and infrastructure costs in shrinking cities. In "Demographic Change and Infrastructural Cost - A Calculation Tool for Regional Planning," Georg Schiller asserts that urban density largely determines the requirements for and costs of urban infrastructure and its operation. Cost calculations for infrastructure generally assume that it will be used at full capacity. This is often not the case in cities with declining populations where the under-use of infrastructure and utilities results in higher per capita costs.<sup>5</sup> Schiller's model compares two scenarios. The first is one of increased suburbanization and green field development with detached single-family homes as the predominant housing type and a dispersed pattern of demolition for vacant buildings in the urban core. The second scenario looks at what Schiller deems the Sustainable Use of Building Stock (SUBS). In this

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<sup>3</sup> B.J. Wattenberg, *Fewer: How the New Demography of Depopulation will Shape Our Future*, Chicago: Ivan Dee, 2004.

<sup>4</sup> "Infrastructure Will Change Significantly as Population Inevitably Declines Towards a Sustainable Level," Tim Prosser's Futuring Weblog. <http://timprosserfuturing.wordpress.com/2008> Retrieved: 03/12/2009.

<sup>5</sup> Georg Schiller, "Demographic Change and Infrastructural Cost - A Calculation Tool for Regional Planning," Paper proposed for Economics of Urban Sustainability (SUE-MoT) Conference, Glasgow, 2007.

scenario, development is more balanced between a central city and its suburbs, there is a greater emphasis on higher density residential development and infill development, and the demolition of vacant buildings is targeted in areas in conjunction with the decommissioning of infrastructure. His findings suggest that an active interdependence between regional planning and infrastructure planning is needed to achieve efficient infrastructure networks, particularly in a context of population decline.<sup>6</sup>

The US Environmental Protection Agency (EPA) defines sustainable infrastructure as a range of practices that “...encourage utilities and their customers to address existing needs so that future generations will not be left to address the approaching wave of infrastructure needs that will result from aging infrastructure.”<sup>7</sup> The EPA’s aim is to reduce the potential gap between water funding needs and spending at the local and national level.

Although the EPA is specifically referring to water and wastewater infrastructure, these principles also apply to transportation and energy networks. As the following subsections of this report suggest, many of the most promising opportunities for improving the management of urban infrastructure in shrinking cities relate to developing sustainable practices rather than to de-commissioning water and sewer lines, roads and bridges, and/or power lines.

## **Water | Wastewater Management**

Water and wastewater infrastructure includes pipes, conveyances, treatment facilities, and other associated assets that are used to retrieve, transport, and treat potable water, wastewater, and stormwater. All of these water-related infrastructures are dealt with simultaneously in this study, but separating them may be appropriate in more detailed analyses that can follow.

Recent research from Germany analyzes wastewater infrastructure in a context of population decline as an emerging challenge for sustainable development in the wastewater sector.<sup>8</sup> In “Demographics as a new challenge for sustainable development in the German wastewater sector,” Holger Schlör et al discuss the German infrastructure network, which was built in the 19th century to supply a growing population with water and energy. Germany’s 3.3 million kilometer-long grid-bound system was built over the last 160 years. As in the US, grid-bound infrastructure has a very long investment cycle and it is not easily adaptable to new uses when demand decreases. Also, grid-bound infrastructure cannot easily be thinned out in response to population loss because the integrity of the grid must be maintained. In Germany, only 2.4% of the total sewer system was constructed in the past five years. Although sewage networks can have life span of up to 100 years, most of the German sewer system is older than this and will have to be renewed in the coming years.<sup>9</sup>

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<sup>6</sup> Ibid.

<sup>7</sup> US Environmental Protection Agency. Sustainable Infrastructure for Water and Wastewater. <http://www.epa.gov/waterinfrastructure>. Accessed: March 12, 2009.

<sup>8</sup> Schlör, H. Hake, J-H and Kuckshinrichs, W. (2009). “Demographics as a new challenge for sustainable development in the German wastewater sector.” *Int. J. Environmental Technology and Management*. 10(3/ 4): 327-352.

<sup>9</sup> Ibid, 342.

For infrastructure services, a large percentage of the cost is determined by long-term, fixed expenses. In Germany, 75% of the wastewater costs are fixed expenses, which occur independently of the volume of water handled. As a result, per capita wastewater costs rise in response to population decline.<sup>10</sup> In the German research, three scenarios are modeled which demonstrate that soaring wastewater costs will most greatly impact the regions in Germany where incomes are the lowest and population decline has been the highest.<sup>11</sup> A similar correlation may occur in US cities, although further research is needed to determine if this is the case.

In the US EPA's guidelines for asset management, utilities are encouraged to understand the condition of all aspects of the water and wastewater network and make risk-based decisions to establish maintenance priorities.<sup>12</sup> In general, an asset management approach consists of five steps:

1. Inventory assets and assess their condition.
2. Prioritize assets for service based on their likelihood of failure and their importance.
3. Plan and schedule infrastructure acquisition, maintenance, repair, and renewal activities.
4. Implement the plan and a scheduling regimen to accompany it.
5. Monitor progress and alter the plan and its implementation as appropriate.

Management strategies focus on ways to optimize the use of physical infrastructure and on the criticality of infrastructure assets. Cities need to know their assets, assess the likelihood of failure in particular aspects of the network, and determine the relative consequences of that failure. This is especially important in shrinking cities because of the financial pressures these cities face and the changing impacts of continued population decline on prioritization processes. These same factors may also affect infrastructure management activities, as the appropriate mix of acquisition, maintenance, repair, and renewal efforts may vary depending on population trends and densities.

As in the German study, the EPA literature notes that the age of water and wastewater infrastructure does not, in and of itself, point to problems. As long as a system is well-maintained, it can operate effectively for many years. Treatment plants often have a useful life of 20-50 years before they need to be expanded or rehabilitated.<sup>13</sup> The life cycle of a pipe can range from 15 to over 100 years, depending on the type of material and the environment. In considering whether a city can shut down or mothball portions of the collection system in an effort to reduce operating and maintenance costs, sewer materials need to be inventoried.

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<sup>10</sup> Ibid, 345.

<sup>11</sup> Ibid, 347.

<sup>12</sup> US Environmental Protection Agency. Sustainable Infrastructure for Water and Wastewater, <http://www.epa.gov/waterinfrastructure>. Accessed: March 12, 2009.

<sup>13</sup> Ibid.

Older steel pipes, for example, can last much longer than newer pipes made of concrete.<sup>14</sup> Another factor in decision-making is that water lines and older pipe materials may degrade more quickly without flowing water, as sometimes occurs in areas with significant population loss and reduced demand.<sup>15</sup>

Current and projected population patterns must be taken into account when considering an approach that shuts down some sections of the sewer network and removes particular areas of a city from service. The costs of decommissioning sewers or water lines must also be considered. These costs may be considerable and, in some cases, they may far exceed any long term savings associated with reduced maintenance, repair, and replenishment. However, decommissioning water and wastewater infrastructure might be a cost effective alternative in areas with substantial population loss in which decommissioning can be accompanied by the relocation of remaining residents and businesses. Given the physical and political challenges of completely decommissioning parts of a sewer or water network, we also looked at whether water and sewer districts can do productive things with excess capacity. For example:

- Can a sewer district in an area of declining population treat wastewater from surrounding communities by investing in interceptor sewers that would diminish the need for new treatment facilities in outlying areas?
- Can a sewer district take and treat septage from private haulers?
- To what extent are water and waste water services already regionalized? Are there opportunities for increased regionalization? This can take many forms – shared infrastructure, shared management, and the integration of water and wastewater utilities.

We also looked at whether increased vacancy in shrinking cities can provide opportunities for stormwater retention and the restoration of water balance, restoring natural hydrologic function by reducing impervious surfaces and increasing vegetation in urban neighborhoods. This type of green infrastructure is not intended to replace storm sewers, but to supplement sewer systems in ways that reduce surface runoff, flooding, and erosion, as well as long term costs associated with stormwater management and the regulatory requirements that are increasingly associated with it.

To explore these issues, we interviewed the following water and wastewater professionals:

- Frank Greenland, Director of Watershed Programs and Kyle Dreyfuss-Wells, Manager of Environmental Programs, Northeast Ohio Regional Sewer District (NEORS)
- Thomas Marsalis, Deputy Commissioner and Elie Ramy, Consulting Engineer, Cleveland Division of Water Pollution Control
- Andrew Watterson, Director of the Office of Sustainability, Cleveland Water Department
- Steve Allbee, US Environmental Protection Agency, Washington D.C.

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<sup>14</sup> Ibid.

<sup>15</sup> Prof. Dr.-Ing. Raimund Herz, Buried Infrastructure in Shrinking Cities, International Symposium “Coping with City Shrinkage and Demographic Change– Lessons from around the Globe” Dresden, March 2006.

In identifying potential areas for cost-savings, we discussed management changes focused specifically on shrinking cities, as well as general management changes (applicable to all cities) that could be usefully applied in shrinking cities. Specific discussion topics included:

1. Shut down or decommission water lines or sewer lines. This might reduce maintenance and repair costs for pipes and/or sewers in areas of low demand and/or declining population.

*Advantages*

- Reduce operation and maintenance costs for areas that are decommissioned.
- Provide disincentive for development in declining areas.

*Disadvantages*

- Up front costs to shut down or decommission.
- Could impact overall functioning of the infrastructure if key portions are shut down.
- May add long term costs if these lines prove necessary to reinstate in the future.
- Eliminating service in some areas may be costly to some property owners and controversial.

Cleveland Division of Water Pollution Control staff indicated that there are 1,200 miles of sewers in the utility's jurisdiction, managed by 160 employees. Consequently, there is not much savings from decommissioning as it is expensive to do and the area of the decommissioning effort would have to be very large to save enough in operating costs to pay off the decommissioning costs. Also, even if water and sewer lines were decommissioned, there might still be new infrastructure needs that would have to be addressed through later redevelopment processes.

2. Use slip liners for wastewater collection systems to minimize inflow and infiltration, and perhaps also the long term costs of stormwater management (retention basin construction and maintenance, treatment overflow management, fines for wastewater permit violations, etc.).

*Advantage*

- Reduce inflow and infiltration and the economic and public health costs that flow from them.

*Disadvantages*

- Costs for installation.
- Savings could be marginal in some cases.

Our interviews with Cleveland Division of Water Pollution Control staff revealed that, in the City of Cleveland, 91% of sewers are combined sewers and 9% are separated. Slip lining and re-sealing is being carried out to address inflow and infiltration and to correct for poor condition. These lining efforts are not specifically in response to population decline. Instead, they are intended to remove excess flow and correct outdated infrastructure which could leak, be dangerous, or otherwise need attention.

3. Explore ways to use excess water and wastewater management capacities. Water and wastewater utilities in shrinking cities could, for example, make their water supply and wastewater collection, treatment, and management capacities available for use by surrounding communities via water line extensions, interceptor sewers, or other means. Septage haulers might also be encouraged to use central wastewater treatment facilities to dispose of private and small community septage.

These kinds of changes hold the potential for several kinds of savings. First, by using larger proportions of existing water and wastewater management capacities, per unit costs are likely to be reduced – particularly if they are offset by additional revenues from new users in surrounding communities. Second, more extensive use of existing capacities could reduce long term capital and maintenance costs for new services in surrounding communities. And finally, many smaller communities are faced with the prospect of managing significant water and wastewater infrastructure with limited expertise and/or staff. Staff from major existing utilities might be able to help fill these management voids in cost effective fashion.

#### *Advantages*

- Reduce per unit treatment and disposal costs.
- Create revenue flows from surrounding communities.
- Create opportunities for regional collaboration.

#### *Disadvantages*

- In some areas, this is already being done so cost efficiency gains may not be significant.
- Creates additional management burdens and the potential for politicization.
- Could promote further out-migration of residents and suburban sprawl without careful planning for sewer extensions.

NEORS staff indicated that the district is currently providing services to outlying communities and septage haulers and these services produce additional revenue. They also indicated that NEORS could expand its service area further to use excess capacity. They noted that success in this area requires effective intergovernmental collaboration.

By contrast, there is no authorization for the City of Cleveland's Division of Water Pollution Control to expand in this way and it is not being sought at this point in time. It could help produce revenue in selected cases, but could also draw resources away from needs in the City of Cleveland.

Our interview with the director of Cleveland's Sustainability Office revealed a reluctance to reduce excess capacity in water infrastructure. Although the city's pumping stations are currently operating at only 50% capacity, this excess capacity provides a competitive advantage in terms of attracting water-intensive industries. The recently adopted Great Lakes Compact limits the amount of water that can be pumped from Lake Erie to current levels. If capacity is reduced now in response to lower demand, it could not be reinstated later if demand increases.



4. Asset management improvements. Ascertain whether existing utilities have complete inventories of their assets (water lines, collection systems, pump stations, treatment facilities, etc.), their condition, and the criticality of their services. Including assessments of the numbers of people and businesses served, locations of particularly vulnerable populations (hospitals, nursing homes, etc.) and expected long term needs would also be valuable here. By developing and managing large utilities through this kind of data driven framework, decision-making regarding both cost reductions and service improvements can be improved.

*Advantages*

- Could lead to large and significant long term cost reductions and service improvements.
- Does not require large up front capital costs.
- Consistent with national and international trends in managing water infrastructure.

*Disadvantages*

- Require top management buy-in, concerted effort, and perhaps culture change.
- Requires up front investments in data and analysis.
- May be difficult to quantify cost reduction and service benefits.

Our interviews revealed that the City of Cleveland has an asset management system but they are working to improve it with a new GIS system. Their current program addresses asset inventories and condition assessments, but not criticality and impact assessments.

NEORS is also collecting inventory and condition assessment information, but it is still working to clarify the most useful ways to analyze the resulting data so it can help them prioritize actions and develop optimal service and maintenance plans.

5. Make greater use of distributed community stormwater management practices such as rain-gardens, rain barrels, and open space preservation to reduce the long term costs of flooding and stormwater management (retention basin construction and maintenance, treatment overflow management, fines for wastewater permit violations, etc.)

*Advantages:*

- Distributed stormwater best management practices can make up for under-design of centralized systems.
- It may also reduce combined sewer overflow volumes, although these practices are most effective for containing the first one to two inches of rainfall and are often overwhelmed in heavier storm events.

*Disadvantage:*

- May not produce a large reduction in impermeable surface, although it is worth investigating whether large scale elimination of impermeable surface would help with CSO issues. However, the tendency to replace pavement with grass may minimize the potential for improvement since grass does not absorb water as well as other kinds of vegetation.
- There are costs associated with these services just as there are with any other community improvement endeavor.

Officials with the Cleveland Division of Water Pollution Control, NEORS, and the Cleveland Water Department all indicated that efforts are being undertaken in this area. NEORS officials indicated that the District is exploring green infrastructure practices as a component of the region's overall Long Term Control Plan for CSO. NEORS highlighted that since Northeast Ohio is under a federal mandate to drastically reduce the number of annual CSO occurrences, flexibility is necessary from USEPA to enable the District and partners such as the City of Cleveland to evaluate the potential for green infrastructure to address CSO issues.

### **Transportation**

Transportation infrastructure encompasses materials and management processes used to transport persons, goods, and services. It includes roads, bridges, freeways and highways, as well as assets used to support public transportation.

Shrinking cities may be able to take a triage approach to managing roads and bridges. There is an intentional redundancy in urban transportation networks to allow for more than one way to get to any given destination. By strategically eliminating some aspects of this redundancy, beginning in places where the condition of the roadway network is in worst condition, cities may be able to reduce infrastructure costs while maintaining an acceptable level of service and access.

According to the Urban Land Institute, cities across the country (both shrinking and growing) are facing challenges related to aging infrastructure. About 24 percent of the country's major roads are in poor to mediocre condition, and 25 percent of bridges are structurally deficient or obsolete.<sup>16</sup> In cities with declining populations, roadway congestion tends to be less of an issue, but the need to maintain an integrated road network that connects the central cities to suburbs and regions to mega-regions remains a priority. As declining cities compete with growing cities for state and federal resources, clear priorities need to be established so that aging infrastructure in declining cities will be maintained and renewed in the most cost-effective ways.

Decommissioning existing roads could reduce the overall costs of road maintenance by reducing the road surface to be repaved, replaced, and plowed. Furthermore, when roads are eliminated, services like trash pick-up and street cleaning could also be eliminated. However, choosing which roads to decommission is difficult because reduced access for remaining residents and businesses will have negative impacts on property values. Also, connections between adjacent areas of city need to be maintained, so pinpointing the locations and extent of roadway removal can be difficult. As such, vacating or legally abandoning roads in response to population decline is not a widespread occurrence in US cities. In "New

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<sup>16</sup> Urban Land Institute and Ernst & Young, Infrastructure 2008. Washington, DC: ULI-the Urban Land Institute, 2008, p.11.

and Innovative Approaches to Infrastructure Management: Seeking Sustainability,” Gary Hamer cites the efforts of the City of Youngstown, Ohio as one example where roadway decommissioning is being considered on a large scale.<sup>17</sup>

A key question to consider is whether it will be cost-effective to reduce capacity through road decommissioning. Cost savings from eliminating roads will depend on the immediate cost of deconstructing a road and the assumption that it will not need to be reconstructed in the future. There are significant capital costs associated with removing roadways. In addition to the expense of removing the road, the site will need to be re-graded and possibly barricaded to prevent unauthorized vehicular use and illegal dumping. In some cases, the surrounding community might request that the site of a former road be landscaped, turned into a pedestrian path, or transformed into another type of public amenity. In most cases, a cost/benefit analysis will be needed to determine whether the up-front costs of removing a road can be recaptured over time through reduced maintenance costs, and how long the period of return will be. A city must also assess whether it is better to make on-going roadway investments that retain existing capacity for future needs, which can be difficult to predict.

Pavement recycling for decommissioned roads is one way to offset the cost of road removal. Recycled concrete and asphalt can be reused elsewhere in the immediate region, reducing the cost of road construction in parts of the region where the population is stable or growing. Recycling requires end users of secondary products. In our conversations with Recycled Materials Company, Inc., we learned that a minimum of 50,000 tons of recycled concrete per year are needed to support a recycling operation; 200,000 tons is the preferred amount for a self-supporting and profitable operation.<sup>18</sup> Ideally, a concrete recycling facility should have a ten-mile service radius. Concrete is a heavy material that is costly to transport. If input or output material needs to travel more than ten miles, the return on investment becomes marginal.<sup>19</sup>

**Freeways** In *Shifting Urban Priorities: The Removal of Inner City Freeway in the United States*, Francesca Napolitan et al discuss the removal of redundant freeway infrastructure that has occurred in several U.S. cities including San Francisco, Milwaukee, New York, and Toronto. In Cleveland, plans are being developed to decommission part of the Shoreway and convert it into a 35 mile-per-hour boulevard. None of these projects have emerged in response to population decline. Instead, the determining factors for freeway removal are:

- The freeway’s condition, and whether there are concerns about its integrity and structural safety;
- A window of opportunity in which freeway removal is able to gain serious consideration;

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<sup>17</sup> Gary Hamer, *New and Innovative Approaches to Infrastructure Management: Seeking Sustainability*. Public Entity Risk Institute. Retrieved: 03/11/2009. [https://www.riskinstitute.org/peri/component?option,com\\_bookmarks/Itemid,44/catid,14/navstart,0/task,detail/mode,0/id,885/search,\\*/](https://www.riskinstitute.org/peri/component?option,com_bookmarks/Itemid,44/catid,14/navstart,0/task,detail/mode,0/id,885/search,*/)

<sup>18</sup> Recycled Materials Company, Inc., Arvada, Colorado, <http://www.rmci-usa.com/>.

<sup>19</sup> Ibid.

- The value of mobility is lower than other community objectives such as economic development or improved quality of life; and
- Elected officials and community leaders who value these other benefits more than they value the benefits associated with freeway infrastructure.<sup>20</sup>

What are the implications for shrinking cities? Is it beneficial to decommission and remove aging freeway infrastructure rather than reconstruct freeways and bridges? How does the freeway infrastructure funding model (in which reinvestment is a mixture of federal, state, and local funds) factor into decision-making in shrinking cities? Does the loss of mobility and economic development potential associated with an extensive freeway network outweigh the benefits of reduced infrastructure costs?

**Public Transit** In cities with declining and deconcentrated populations, transit systems can adapt by offering less frequent service. Bus routes can be modified to retain service to remaining residents and reduce service to areas of greatest population loss. However, changes in service must be made carefully because demographic factors have significant impacts on transit usage. Shrinking cities are often characterized by high levels of poverty and lower than average rates of car ownership. This results in a higher percentage of people who rely on public transportation. Tenants may have the ability to relocate in response to changes in a transit system; homeowners typically have less flexibility in this regard.

According to Anthony Downs of the Brookings Institution, it takes a density of at least 4,000 people per square mile to support public transit.<sup>21</sup> As a city's population becomes dispersed, fixed transit routes becomes less effective. A neighborhood targeted for rail transit development because of its high population density may no longer support rail transit development two or three decades from now due to population shifts. Buses allow for greater flexibility as a city's population changes. Cities also need to be able to accommodate a shifting job market. As business centers develop outside of the traditional business districts, public transportation needs to adapt to these changes.

We discussed transportation infrastructure issues with the following individuals:

- Jomarie Wasik, Director, City of Cleveland Department of Public Service
- Norbert Delatte, Professor of Civil and Environmental Engineering, Cleveland State University, Civil and Environmental Engineering Faculty

Director Wasik indicated that there has been no significant effort to decommission roadway or bridge infrastructure in the City of Cleveland. However, several bridges and roadways had been closed because they represented safety hazards and funding for appropriate repairs was

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<sup>20</sup> Francesca Napolitan and P. Christopher Zegras, *Shifting Urban Priorities: The Removal of Inner City Freeway in the United States*, TRB 2008 Annual Meeting, revised for TRB CD-ROM: November 15, 2007.

<sup>21</sup> Anthony Downs, *Traffic: Why It's Getting Worse, What Government Can Do*. The Brookings Institution Policy Brief #128, January, 2004.

not available. She also noted the political sensitivity of reducing services in neighborhoods with declining populations and the Mayor of Cleveland's commitment to maintain basic public services for all residents in the City of Cleveland.

As with water and stormwater infrastructure, we identified potential areas for cost-savings in transportation infrastructure—both management changes specifically for shrinking cities and general management changes (applicable to all cities) that could be usefully applied in shrinking cities, including:

1. Eliminating some existing roads and recycling the concrete/asphalt. The elimination of roads would reduce maintenance and management costs and there could be a revenue flow associated with recycling concrete and asphalt.

*Advantages*

- Reduces or eliminates road maintenance costs.
- Recycling concrete could produce a revenue flow
- Creates additional space for other purposes.
- Reduces the area of impermeable surface in the city.

*Disadvantages*

- Road deconstruction may prove costly to public entities.
- Road deconstruction may prove costly and controversial to some property owners.
- Recycling revenues may be one-time only and markets for it may not be stable.
- Once removed, the roads will not be available for future use.

In our interviews, it became clear that decommissioning roads is likely to be a politically sensitive exercise. However, these same discussions made it clear that decommissioning can occur on a de facto basis in cases where transportation funding is limited. As with other forms of infrastructure removal (water and wastewater, for example), decommissioning existing roads would have a high initial capital cost. The cost of rebuilding infrastructure in response to the future is likely to be high. Therefore any plans to eliminate infrastructure must be carefully considered and would be appropriate only in places of significant depopulation with very limited prospects for future growth.

However, removing impermeable surfaces may yield improvements in the operation of the hydrological cycle in urban areas with declining populations. These improvements, in turn, hold the potential to reduce stormwater management costs associated with combined sewer overflows (CSOs) in the future. Further study is necessary to determine whether road removal efforts might yield sufficient reductions in stormwater flows to enable reductions in future stormwater management costs.

2. Narrowing roads in response to reduced traffic volumes.

*Advantages*

- Roads could be narrowed in conjunction with scheduled roadway repair or replacement, possibly reducing long-term maintenance costs.
- Creates opportunities for wider sidewalks and/or deeper tree lawns.
- May reduce the area of impermeable surface in the city.

#### *Disadvantages*

- Would not reduce maintenance costs as much as decommissioning roadways.
- Narrowed roads would be difficult and costly to expand if future traffic volumes require greater capacity.
- There are upfront costs for narrowing existing roads.

Road narrowing has occurred in limited situations in the City of Cleveland. Detroit Avenue (on the city's west side) has been narrowed through the Gordon Square Arts District to allow for streetscape enhancements and traffic calming. The cartway across the Detroit Superior Bridge was also narrowed to allow for a wider sidewalk and dedicated bike lane. These projects were not undertaken in response to population decline. In fact, the Detroit-Shoreway neighborhood has a stable population, with modest growth projected in the 2010 census. Instead, both projects took advantage of reduced traffic volumes to improve aesthetics and accessibility for pedestrians and bicyclists.

3. Re-routing some existing bus and public transit routes to focus on areas where the need remains the highest and/or alter the forms of public transportation to reduce costs.

#### *Advantage*

- Reduces vehicle and personnel costs associated with routes that have minimal demand.

#### *Disadvantages*

- Reducing or eliminating services may have profound negative impacts on some populations.
- Likely to be controversial.

Our interviews did not yield significant additional insights relating to re-routing existing bus and public transit routes, so this is an area that may be appropriate for further study and analysis.

4. Assess whether expansions in public transportation might reduce the need for private vehicular transportation in cost effective ways. While this would involve significant up-front investments, it might also enable cost savings relating to new roads, road maintenance, and environmental and public health impacts. It might also benefit from state and federal subsidies, which could also be assessed.

#### *Advantages*

- Potential for long term economic savings.
- Potential for significant environmental and public health improvements.
- There may be subsidies available for this kind of investment.

#### *Disadvantages*

- The amount of up-front investment necessary is likely to be very large.
- May require cultural change of significant proportions.

Our interviews did not yield significant additional insights relating to the appropriate mix of public and private transportation in shrinking cities. This may also be an area that would be appropriate for further study and analysis.

5. Asset management improvements. Ascertain whether existing authorities (state, local, and regional transportation agencies) have complete inventories of their assets (roads, buses, trains, tracks, etc.), their condition, and their criticality to services for the public. Including assessments of the numbers of people (or businesses, etc) served and expected long term needs would also be valuable here. By developing and managing existing transportation infrastructure through this kind of data driven framework, decision-making regarding both cost reductions and service improvements can be improved.

*Advantages*

- Could lead to large and significant long term cost reductions and service improvements.
- Does not require large up front capital costs.
- This approach is increasingly being used in infrastructure management and investments and it appears consistent with current infrastructure management trends.

*Disadvantages*

- Requires support from top management, concerted effort, and perhaps culture change.
- Requires up front investments in data and analysis.
- May be difficult to quantify cost reduction and service benefits.

Our interviews reinforced the potential value of asset management programs, as well as a need to improve understandings and operating procedures associated with their conduct. The Cleveland Public Service Department has been using a software program to inventory their transportation infrastructure assets and keep track of their condition. However, the city is still working to identify how best to use the data they are compiling to set priorities for service maintenance, repair, and replacement activities.

## Energy

Energy infrastructure includes power production facilities and distribution lines, as well as other assets needed to deliver power service to residences, businesses, and others in the area.

There is little direct research available on the management of energy infrastructure in a context of population decline. We did find one source. “Europe’s Energy Deficit” by Rosamund McDougall, which correlates energy issues and population decline in Europe.<sup>22</sup> Europe is facing a sharply rising energy deficit which may lead Europeans to reassess current policies that promote population growth, since energy demands increase proportionately to population growth.<sup>23</sup> If the EU population declines to a more environmentally sustainable level, this could resolve the energy gap and significantly reduce greenhouse gas emissions.<sup>24</sup> In US cities, energy gaps are much less common, aside from peak periods of energy use in the summer months. In cities that have lost population and industries, power-generating capacity may exceed demand.

The European Commission’s Energy Road Map (March 2007) sets a goal of 20% of Europe’s overall energy needs to come from renewable sources by 2020.<sup>25</sup> In the United States, similar goals are being set at the state level through renewable portfolio standards, which have now been set in over half of the states.<sup>26</sup> In “Small Green and Good,” Catherine Tumber makes a case for shrinking cities as key locations for renewable energy production, noting that these cities, with their large parcels of vacant, low-cost land could serve the alternative energy industry well.

Renewable energy technologies need space that dense and growing cities cannot easily provide. For example solar power can occur on rooftops and awnings in big cities, but offers much greater potential when staged on ground mounts on brownfields, suburban greyfields, or vacant land. Currently, the general rule is that one megawatt of solar-generated power (enough to power about 100 homes) requires about eight acres of land.<sup>27</sup> Thus, in the US context, vacant land in shrinking cities holds some promise as potential sites for renewable energy production, including solar, geo-thermal, wind energy, and bio-fuels.

Currently, the renewable energy industry cannot compete effectively with fossil fuels such as coal, natural gas, and oil, which together provide about 86% percent of electrical power in the United States (US DOE). It has been difficult for renewable energy sources to achieve “grid parity”—the point at which renewable energy costs the same or less than power from

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<sup>22</sup> Rosamund McDougall. (2008). “Europe’s energy deficit: a population dilemma.” *Environmentalist*. 28:155–157.

<sup>23</sup> *Ibid*, 155.

<sup>24</sup> *Ibid*, 156.

<sup>25</sup> *Ibid*, 157.

<sup>26</sup> Barry Rabe. *Race to the Top: The Expanding Role of State Renewable Energy Standards*, PEW Charitable Foundation, Global Climate Change Research Program, June, 2006.

<sup>27</sup> Catherine Tumber, “Small, Green, and Good: The role of neglected cities in a sustainable future.” *Boston Review*. March/April, 2009. Retrieved: 03/11/2009. <http://bostonreview.net/BR34.2/tumber.php>.



prevailing sources. The energy grid, built decades ago for local utility monopolies and now used by a deregulated national energy industry, is in disrepair and it is oriented toward large “base loads” traveling over long distances to major population centers. The grid is not well-suited to storing or transferring small, supplementary loads of electricity—the kind of loads produced by renewable energy sources. Localizing energy through renewable sources also limits grid transmission loss, which can run as high as 10 percent.<sup>28</sup>

The existing energy grid uses large, centralized generating facilities that operate at a regional level. In contrast, renewable energy technologies use smaller, distributed facilities that operate at the local level. As such, renewable energy facilities have greater flexibility in terms of their locations and may be adapted in response to population shifts and changing residential densities. The Portland, Oregon–based *Post Carbon Cities* project promotes policies to “relocalize” cities by decentralizing energy production. These kinds of policies may prove particularly useful for shrinking cities, which have the land available for the development of renewable energy technologies.

To learn more about options for increasing the efficiency of energy infrastructure in shrinking cities, we interviewed Ivan Henderson, Commissioner of Cleveland Public Power and Karl Benstrom, a power engineer who has worked for more than twenty years with several electric utilities, including one in which populations were declining. These interviews – along with the literature we reviewed – yielded discussions regarding the following electrical infrastructure management options for shrinking cities.

1. Eliminate energy infrastructure and discontinue service to depopulated areas of a city.

*Advantages*

- May reduce costs, since there would be fewer lines to maintain.
- Could make it faster and easier to determine the causes of power outages since the overall grid would be reduced.

*Disadvantages*

- Difficult and expensive to restore service at a later point if an area regains population.
- Lines in under-used areas may be needed to service other areas.
- Political issues involved in identifying areas for decommissioning—likely to be controversial.

Karl Benstrom indicated that it often does not make sense to completely remove power infrastructure because it is difficult to predict what will happen in the future and the infrastructure may be needed again. If a utility needs to reinstall infrastructure at a later date, this will typically be much more costly than maintaining it in the interim period. Also, lines in depopulated areas often are needed to service other areas where population

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<sup>28</sup> Ibid.

is stable or growing. Redundancy in energy infrastructure is desirable since under-used infrastructure provides a back up for the rest of the network, particularly in emergency situations. He also noted that the costs of taking down infrastructure are not just engineering and economic. Political and legal factors also become involved because of the need for easements. If a utility doesn't "use it" (even a little will suffice), it may "lose it" (e.g. the rights-of-way necessary to conduct business).

Commissioner Henderson from Cleveland Public Power confirmed many of these insights. He noted that there needs to be service where the customers are. Removing infrastructure is a high cost proposition, he suggested, because it is difficult to know what will happen in the future. City officials hope (and expect) that Cleveland will regain population in some areas and the city needs the infrastructure over the long term to enable that to happen. In the short term, the operational savings from removing infrastructure are not likely to be large.

However, Karl Benstrom indicated that there are things that can be done to make systems more efficient when loading demands fall off considerably due to substantial population decline. For example, changing and reducing transformer sizes will enable their more efficient use. It makes no sense to use large, expensive transformers when smaller, less expensive ones will do. Lines and conductors can also be downsized in response to reduced demand, as long as one can ascertain the level of demand before one undertakes this task. Lines can be rebalanced to improve the relationship between power supplies and demand. Smart Grids are also possible. A Smart Grid delivers electricity from suppliers to consumers using digital technology to save energy, reduce cost and increase reliability. Smart Grids are not typically used in smaller utilities, or even in some of the larger utilities, but improvements in this area hold significant potential for the future.<sup>29</sup>

2. Reduce public lighting costs. This could be done through scheduled down time or elimination of public lighting in under-populated areas and/or making greater use of high efficiency street lights. The effects of scheduled down-time on crime and public comfort would need to be assessed. For energy-efficient lighting, cost savings need to be evaluated relative to installation costs.

*Advantages*

- Likely to reduce costs, and it may do so relatively quickly.
- Targets depopulated areas for reduction or elimination of services

*Disadvantages*

- Darker streets may meet with resistance and some may argue it fosters crime.
- Energy efficient lighting, organizing lighting down times, and/or eliminating lights in some areas would all require up front costs.

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<sup>29</sup> Michael Totty, "Smart Roads. Smart Bridges. Smart Grids", Wall Street Journal, February 17, 2009.

Commissioner Henderson suggested that, over the long term, the use of more energy efficient lighting systems may be a particularly promising option for cost savings. In September of 2008, Cleveland Public Power (CPP) purchased all of the street lights in the City of Cleveland from First Energy. This was done primarily for safety and to improve service to the city's customers, CPP is now looking into more energy efficient lighting fixtures. There is a study underway to ascertain whether these lights are appropriately durable and will function properly in Cleveland. The city has not looked at dimming lights or eliminating them in particular areas, as further research is needed in this area.

3. Increase the generation of decentralized energy with solar panels, geo-thermal, hydro-power, etc. If power generation is decentralized, the owners of the infrastructure may be able to contribute surplus power to the overall electrical grid.

*Advantages*

- Has the potential to produce low cost power in some settings.
- May produce incentives for conservation if power can be sold to utilities.
- There may be federal and state incentives forthcoming in this area.

*Disadvantages*

- May require substantial up front investments
- Investments may not yield steady power streams – need to tie in with existing utilities.

Cleveland is not yet developing these kinds of decentralized energy sources, but they are beginning to look at “net” metering. Net metering would allow the utility to take account of energy flows into the grid as well into the homes and businesses of consumers, and is therefore a potentially important step in enabling the development and widespread use of decentralized energy sources. Utilities in Ohio are becoming increasingly aware of the need to increase the use of alternative energy sources in the future. The state of Ohio recently enacted a Renewable Energy Portfolio standard calling for the future expansion of alternative energy sources. And Cleveland Public Power, a municipal utility that is exempt from this standard, has developed its own renewable energy standard to guide its activities. CPP's standard calls for 15% advanced/renewable energy by 2015, 20% advanced/renewable energy by 2020, and 25% advanced/renewable energy by 2025.

4. Evaluate whether it makes sense to have two utilities serving the Cleveland area. Do two utilities duplicate efforts or do they provide healthy competition? A wide range of factors need to be considered such as energy sources used by each utility, transmission lines, management costs, customer service, etc.

*Advantages*

- Could produce savings.
- A decision to conduct a study might foster improved collaboration.

*Disadvantages*

- Possible resistance from one or both utilities.
- May or may not produce savings – highly uncertain.

Cleveland, Ohio is served by two major electrical utilities. Cleveland Public Power is a municipal utility that has been in existence since the Progressive era in the early 1900s and seeks to provide low cost energy and high quality service to Cleveland residents. The Cleveland Electrical Illuminating Company is a privately owned utility that serves a large portion of northeast Ohio, including Cleveland. It is not clear whether the benefits of competition outweigh the costs of duplication, and significant further research and analysis would be necessary to resolve this question.

5. Asset management improvements. Ascertain whether existing authorities have complete inventories of their assets (energy production facilities, utility lines, poles, support equipment, etc.), their condition, and their criticality to services for the public, and the numbers of people (or businesses, etc) served. By developing and managing existing electric and energy infrastructure through this kind of data driven framework, decision-making regarding both cost reductions and service improvements can be improved.

*Advantages*

- Could lead to large and significant long term cost reductions and service improvements.
- Does not require large up front capital costs.
- This approach is increasingly being used in infrastructure management and investments in it appear consistent with current infrastructure management trends.

*Disadvantages*

- Requires support of top management, concerted effort, and perhaps culture change.
- Requires up front investments in data and analysis.
- May be difficult to quantify cost reduction and service benefits.

Cleveland Public Power uses an asset management system that involves inventorying assets, assessing their condition, and determining their criticality to the overall system. However, criticality judgments do not include impact assessments relating to the numbers and types of establishments served. The utility's asset management processes operate only at larger "substation" levels, rather than at smaller scales corresponding to power supplies for individual residences or small businesses. From Cleveland Public Power's perspective, the asset management process is valuable, but it can reach diminishing returns when applied to smaller scale assets. In these cases, the costs of collecting and analyzing data can exceed the benefits of doing so.

## CONCLUSIONS | NEXT STEPS

When we began this research, we hoped to find a technology or strategy that would enable substantial cost savings by decommissioning large components of costly infrastructure that were no longer necessary due to declining population. We found no such thing. As Thomas Dye suggested over two decades ago, infrastructure tends to be capital intensive and it carries high fixed costs. These costs do not go down with successive marginal reductions in population. This point was re-enforced repeatedly during the course of our research and in our discussions with infrastructure management professionals.

Indeed, we found only handful of areas where the prospects for relatively *short term* cost savings (say, one to three years) and efficiency improvements are promising. It may be possible to make better use of excess water and/or wastewater infrastructure capacities by expanding services to outlying communities and treating septage from outside haulers. In the transportation sector, there may be instances in which particular roads or bridges might be removed or decommissioned, but it appears that this kind of change can be applied only in a limited set of situations – and it may be controversial even then. In the energy sector, making greater use of energy efficient lighting practices in public areas may yield significant cost savings over time, and it is possible that these savings may begin accruing relatively quickly.

What we did find, however, were a series of potential long term opportunities for more efficient and sustainable infrastructure management practices, and some of these opportunities appear to be more apparent and promising in shrinking cities than in cities where population densities remain high and growth is occurring. The paragraphs that follow briefly describe several of these areas of opportunity.

***Asset Management*** All of the major infrastructure management organizations we spoke with support the use of asset management strategies. All are inventorying their assets and making assessments of the condition of each asset to help them guide their priority setting and infrastructure acquisition, maintenance, repair, and renewal activities. However, nearly all of the organizations we spoke with acknowledged that they were still trying to improve and optimize their data collection and analysis capacities to enable them to set clear, known, and defensible priorities for spending limited resources. Because shrinking cities tend to face acute resource constraints, improvements in these analytical processes may be of particular value in shrinking cities. Additional research and training in this area may yield substantial benefits over time.

***Coordinating Across Infrastructures*** Throughout the course of this project, it became clear that relatively minimal attention is paid to ways in which changing practices in one infrastructure management sector may yield costs savings or efficiency improvements in other sectors. For example, while the cost savings accruing to highway departments from decommissioning roads may be minimal, it is possible that removing large quantities of pavement in de-populated areas could yield hydrological benefits that reduce stormwater management costs. Similarly, greater reliance on public transportation may yield substantial reductions in overall energy use and demand. And, if water and wastewater management systems can be simplified and unnecessary service extensions minimized, it is possible that this may reduce long term energy costs. While we do not have hard data to confirm that substantial savings can be achieved through any of these kinds of cross sector changes, it would seem appropriate to investigate these relationships further.

***SMART Technologies*** In all three of the major infrastructure sectors we investigated, we uncovered potential long term opportunities for more efficient and effective infrastructure management<sup>30</sup>. In the electricity sector, advanced metering methods may enable both decentralized energy production from renewable sources and the creation of information that allows citizens and businesses to understand how their behaviors influence the amount and cost of electricity they use. In the transportation sector, it appears likely that new technologies may enable both faster and more efficient reports about congestion and traffic patterns that can yield more efficient time management for travelers, reduced costs, and environmental benefits. In the water and wastewater sectors, new technologies may allow for better and less costly leak detection processes for water systems, and automated systems for predicting failures in levees and for monitoring water quality.

***Harnessing Vacant Lands for Renewable Energy and Stormwater Management*** In recent years, it has become apparent that we need to reduce our reliance on fossil fuels. Unfortunately, our existing infrastructure is not well suited to this task. The electrical grid is not structured to draw energy from a wide range of sources and many alternative energy sources such as solar power require significant land area to be produced in sufficient quantity. Because of vacant land and reduced property values, shrinking cities may hold unusual potential for developing alternative and decentralized energy sources. As federal and state governments invest in projects to expand the proportion of our energy demand that is met by alternative sources, shrinking cities may find that they have a comparative advantage in this area.

Emerging practices in distributed stormwater management and green infrastructure also offer significant opportunities for shrinking cities. Green infrastructure is the use of green spaces, wetlands, parks, forest areas, and native vegetation to manage stormwater naturally, reduce flooding risk, and improve water quality. Green infrastructure can support conventional centralized sewer systems by reducing the amount of stormwater that ends up in the sewer system. These practices are beginning to be used in used in cities across the country, notably

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<sup>30</sup> Michael Totty, "Smart Roads. Smart Bridges. Smart Grids", Wall Street Journal, February 17, 2009.

in Seattle, Portland, Philadelphia, and Chicago. As with the generation of renewable energy, the abundant vacant land and relatively low land costs may give shrinking cities an advantage in terms of implementing green infrastructure practices at a citywide scale.

*Understanding the Costs of Unguided Growth* Throughout the research process, it became increasingly evident that per capita infrastructure service costs are likely to be higher in shrinking cities than in cities that are more densely populated. It was also evident that sprawling patterns of growth in metropolitan regions contribute to both declining populations in central cities and to increasing infrastructure costs. In spite of the obviousness of these findings, we found little evidence that metropolitan areas are quantifying the infrastructure costs associated with unguided patterns of growth. While designing and conducting studies to quantify the infrastructure costs associated with sprawling development patterns is likely to be a large and potentially expensive undertaking, the costs of carrying out these kinds of analyses are dwarfed by the costs of not doing so. In the long term, if patterns of growth which contribute to declining populations in urban centers are to be addressed, we need to understand their costs. We therefore recommend that studies be conducted to assess the costs associated with declining central cities within sprawling regions in order to inform both planning and political processes affecting metropolitan growth.

Because the problems associated with managing infrastructure in shrinking cities are evident in Cleveland and elsewhere, we had hoped to uncover major opportunities for short term cost savings. Unfortunately in this context, the most promising opportunities that we have found are likely to yield substantial benefits only over the long term. Even so, these potential long term benefits may be substantial in the areas described above. And, because of limited resource bases, long term cost efficiencies in all five of these opportunity areas may be particularly beneficial for shrinking cities. In addition, in at least two of these areas – coordinating across infrastructures and harnessing vacant lands for alternative energy – it appears that shrinking cities may hold at least some form of comparative advantage over cities where higher levels of growth are occurring. Further research in all five areas is therefore appropriate to foster more effective and efficient infrastructure management in shrinking cities.

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