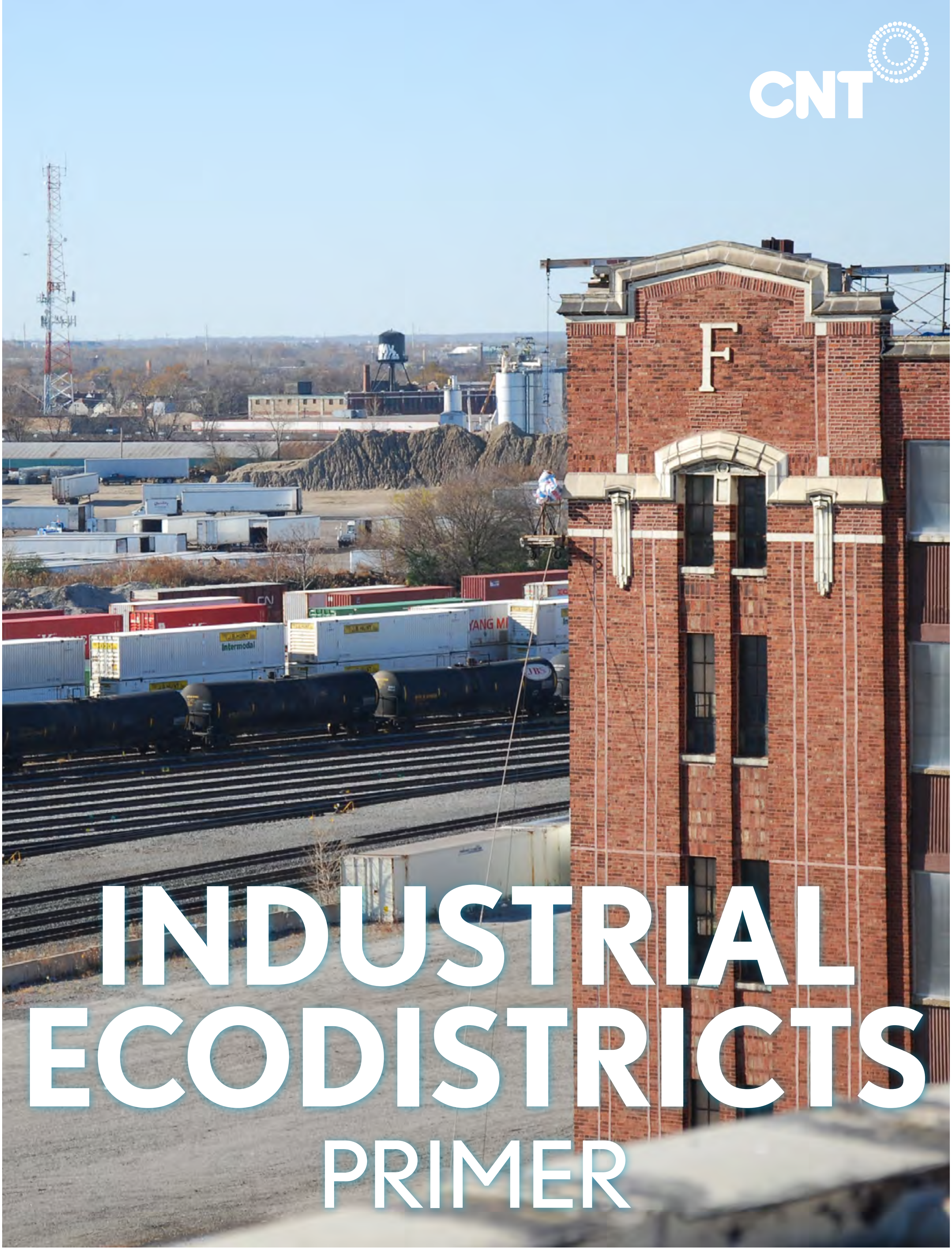

INDUSTRIAL ECODISTRICTS
PRIMER

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Industrial EcoDistricts
Primer

PREPARED BY
THE CENTER FOR NEIGHBORHOOD TECHNOLOGY

JUNE 2017

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OVERVIEW

There are nearly 950,000 more manufacturing jobs in the U.S. today than in 2010.[1] This resurgence presents a major opportunity for communities. As a rejection of inefficient sprawling industrial parks and overseas production, there is growing demand for urban manufacturing locations. But cities that want to take advantage of manufacturing's return need to prepare. An EcoDistrict approach to industrial revitalization can help keep costs down and bring the benefits of manufacturing to a community, while reducing the environmental burdens.

This paper presents CNT's recent research on a range of innovations for Industrial EcoDistricts in the areas of energy, water, transportation, and waste. Our work looks at district-scale interventions through the lenses of: What is it?, Why do it?, and What does it cost? with practical, real world examples and financing strategies to help implementers and decisionmakers create next-generation industrial districts in their communities.

This paper examines:

- **ENERGY:** Renewables, Storage, District Energy, Microgrids, Energy Efficiency, and Demand Management
- **WATER:** Water Efficiency, Demand Reduction, and Water Reuse
- **TRANSPORTATION:** Urban, Transit-Served Locations, Goods Transportation, and Logistics
- **WASTE SYSTEMS**

We also discuss the several essential implementation factors, including site selection, governance, engagement, financing, policy, and documenting benefits.

While all of the strategies and technologies we have looked at are being tried in one form or another, for the most part they have yet to be brought to scale and to be systematically integrated. As we begin to define what infrastructure means in our communities, Industrial EcoDistricts present a way to create jobs while saving energy and water, addressing climate change, and creating an economic benefit for businesses and communities.

1. U.S. Department of Labor, Bureau of Labor Statistics, "Employment, Hours, and Earnings from the Current Employment Statistics survey (National)," Manufacturing employees, seasonally adjusted, Accessed June 2017. https://data.bls.gov/timeseries/CES3000000001

INDUSTRIAL ECODISTRICTS

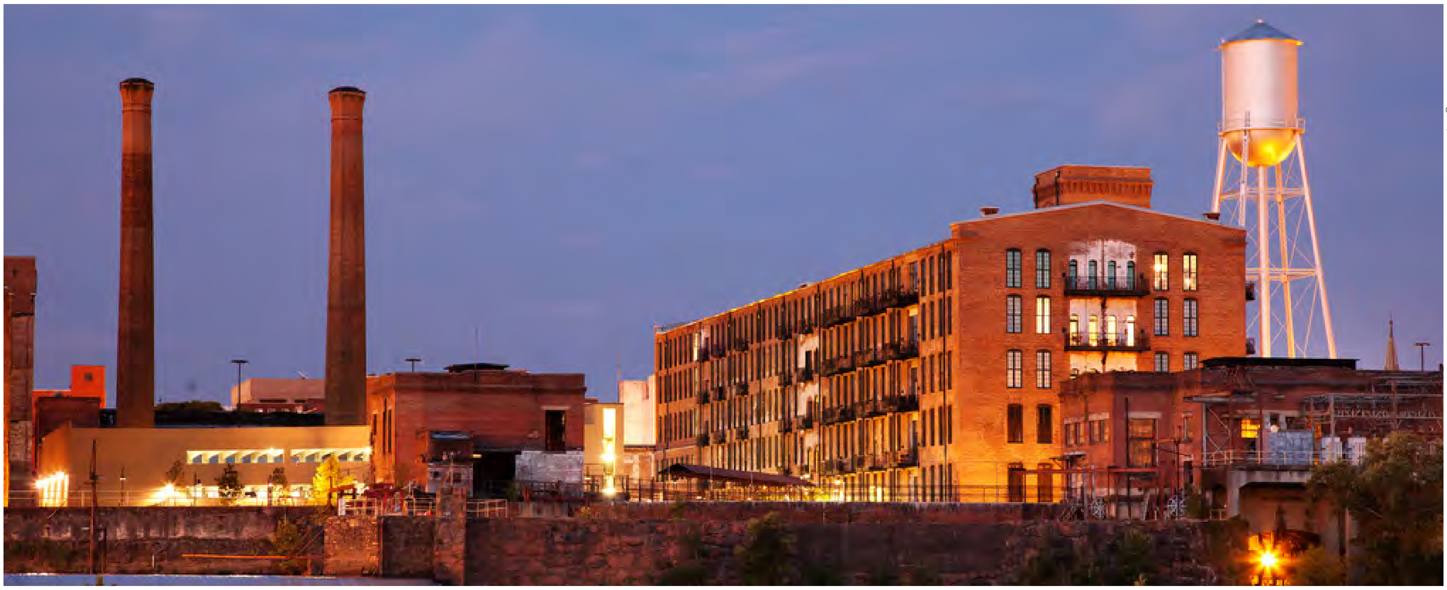

Photo: Keith Milligan, Flickr/Creative Commons

There is much debate today about manufacturing's potential for widespread job creation in the U.S. Given automation trends in the industry, manufacturing may never provide the level of employment anywhere that it did in the past. However, manufacturing jobs are beginning to return to the U.S.—there are nearly 950,000 more manufacturing jobs today than in 2010.[2] This resurgence presents a major opportunity for communities.[3] Manufacturing renewal has received policy and investment attention and has started growing again in the past several years. As a rejection of inefficient sprawling industrial parks and overseas production, there is growing demand for urban manufacturing locations. But cities that want to take advantage of manufacturing's return need to prepare themselves. An EcoDistrict approach to industrial revitalization can help keep costs down and bring the benefits of manufacturing to a community, while reducing the environmental burdens.

WHY ECODISTRICTS

Business as usual development and infrastructure will not serve us as we prepare our cities for climate and economic uncertainties. Equity, Resilience, Climate Protection: These are the three "imperatives" of an EcoDistrict. Any district-scale strategy must have these as its fundamental building blocks. Within these imperatives, the EcoDistrict Protocol—a framework document for creating EcoDistricts—defines six priorities that projects should work toward: Place, Prosperity, Health & Wellbeing, Connectivity, Living Infrastructure, and Resource Restoration.[4]

Reducing resource use provides many benefits to manufacturers, including reduced operational costs, resiliency, product competitiveness, policy compliance, and limited exposure to future resource price risks. The Industrial EcoDistrict primer describes these benefits and digs into the details of energy, water, transportation, and other system innovations that are being used in industrial applications.

2. U.S. Department of Labor, Bureau of Labor Statistics, "Employment, Hours, and Earnings from the Current Employment Statistics survey (National)," Manufacturing employees, seasonally adjusted, Accessed June 2017. https://data.bls.gov/timeseries/CES3000000001
3. See, e.g. the work of the Urban Manufacturing Alliance http://www.urbanmfg.org/
4. EcoDistricts, "3 Imperatives," July 2016. https://ecodistricts.org/get-started/the-ecodistricts-protocol/imperatives/

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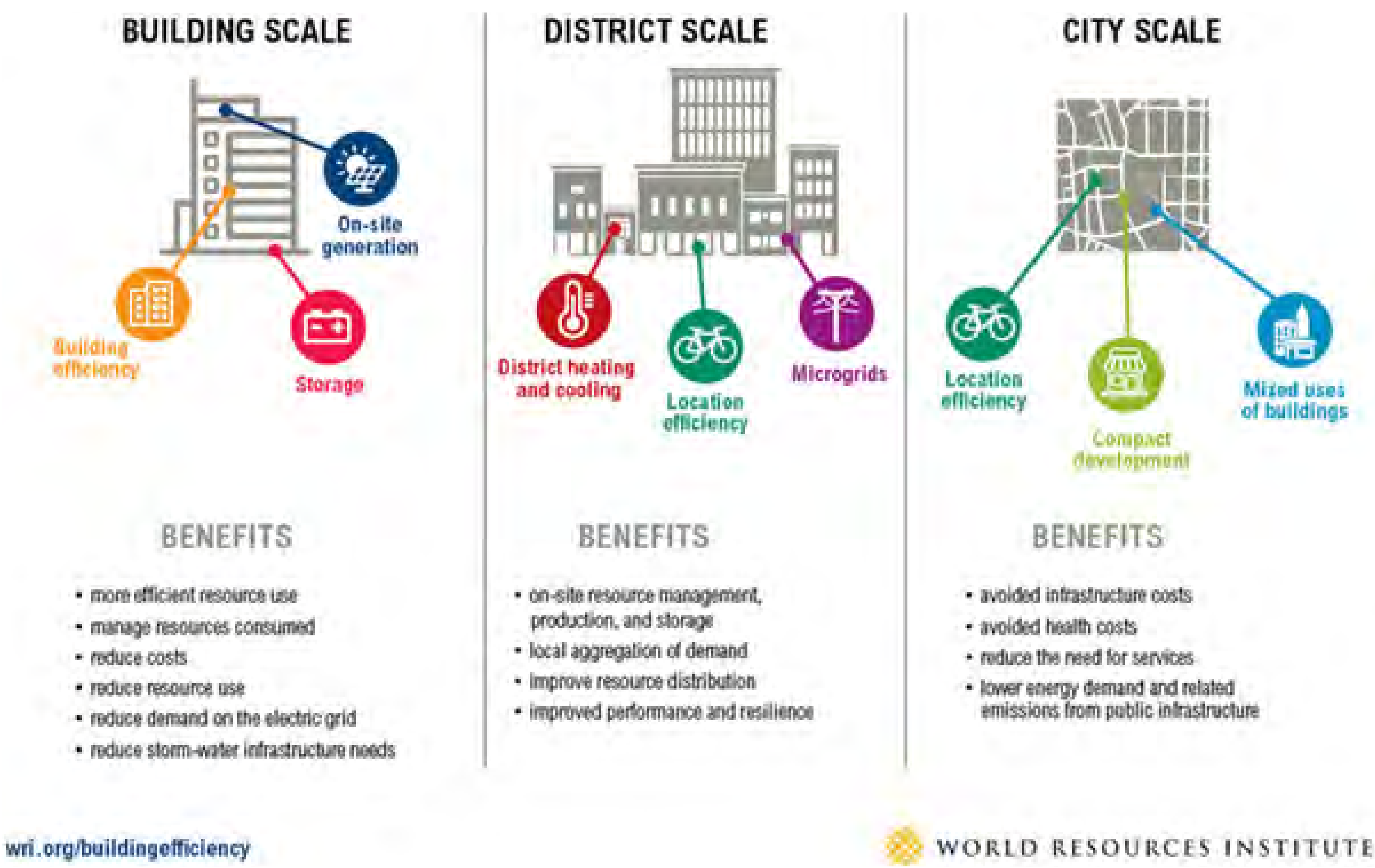
INTEGRATED INFRASTRUCTURE

In the past, our urban infrastructure was most often built as a set of independent systems…perhaps your water and gas pipes were under ground, your electrical wires above, telephone access added later, cable access added on top of that. Today, there are efficiencies to be gained with more integrated systems—heating and hot water systems that use waste heat from power generation, smart systems that predict usage and store power for times of high demand or service interruption, for just a couple of examples. The kind of distributed, networked systems that today's technologies enable can create efficiencies and improve service.

This graphic gives a sense of the scale at which some of these innovations work best. An individual building may be well suited to reduce its individual energy use with insulation and efficient lighting, for example, but at the district scale it becomes feasible to transform the entire energy profile of a set of buildings with district heating, renewable-based microgrids, and more. The larger load and diversity of energy uses at the district scale create more options.



BENEFITS OVER BUSINESS AS USUAL

Industrial EcoDistricts have a wide array of benefits as compared to standard industrial facilities. These include reduced operational costs, improved resiliency in times of climate uncertainty, lower environmental impact, ability to meet special production process needs such as high power quality, competitiveness benefits in the marketplace, and alignment with policy requirements.

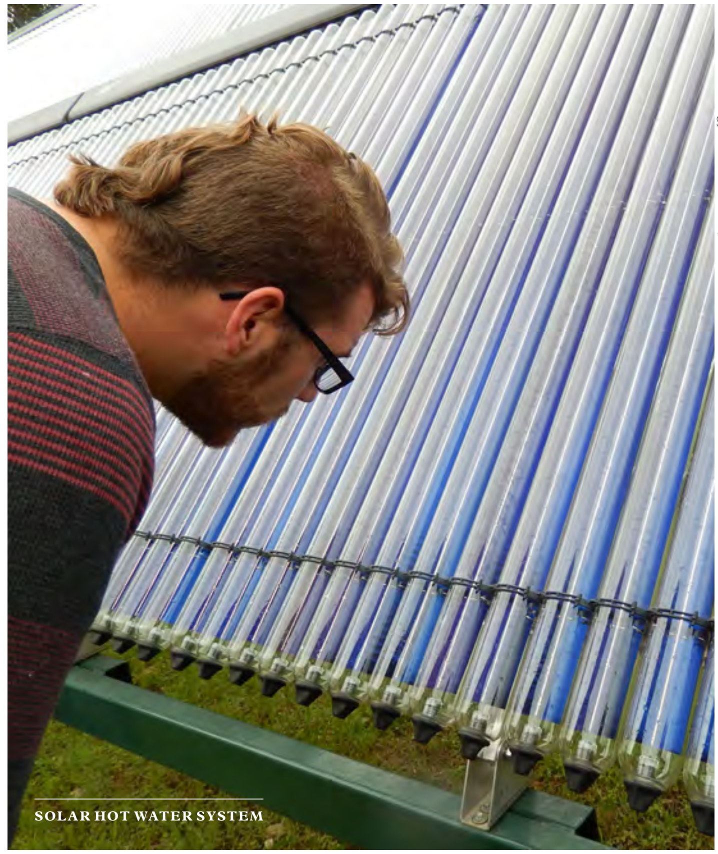
The importance of a given benefit will vary by place, project, and owner. Operational paybacks may be strongest in places with high energy or water costs, but the resiliency benefits of avoiding power outages may be greatest in an area at high risk for major storms.

REDUCED OPERATIONAL COSTS

On-site energy generation from renewable and efficient sources can be a major cost saver over electricity, natural gas, or heating oil purchased from utilities. Similarly, water reuse systems can drastically cut the need to purchase water. Efficiency and demand reduction in energy, water, and transportation all can reduce costs no matter the source. Demand reduction measures should be tuned for the specific uses at a facility to achieve the greatest results. For example, CNT and Navigant recently completed a consultation that looked at opportunities to reduce food manufacturing start-up incubator operational costs, because food production has very specific needs for ventilation and equipment, among others.[5]

IMPROVED RESILIENCY

The resilience benefits of new forms of infrastructure has become an area of particular focus as climate change brings with it historic storms and droughts. Continuing operations in times of grid disruption or water scarcity can be a major cost saver for an industrial manufacturer and bring ancillary community benefits, such as a local source of power for emergency responders to charge communication tools.



SOLAR HOT WATER SYSTEM

Photo: Clean Energy Resource Teams, Flickr/Creative Commons

LOWER ENVIRONMENTAL IMPACT

Across the country, energy systems are moving away from coal-fired power generation to cleaner forms of electricity, and resource efficiency is improving, but the average industrial energy consumer still has a significant environmental footprint. From reducing air pollutants and greenhouse gases to minimizing wastewater discharge, new forms of infrastructure can reduce the environmental impact of production.

SPECIAL PRODUCTION NEEDS

If a particular piece of production equipment or a manufacturing process is sensitive to issues of power quality or water quality, an Industrial EcoDistrict can be designed to address those needs.

5. CNT and Navigant, "Food Incubator Energy Systems Innovation," April 2017. http://www.cnt.org/publications/food-incubator-energy-systems

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CENTRAL MANUFACTURING DISTRICT Chicago, IL

Chicago's Central Manufacturing District (CMD) was the first planned manufacturing district in the United States. At its peak, the CMD's 200 tenants employed roughly 35,000 workers within its 1 square mile footprint—well paying, walkable and transit-accessible jobs. With outstanding rail connections and a broad variety of shared services, the CMD became one of the largest industrial parks in the world. CNT's recent work to reimagine the Central Manufacturing District for the 21st century as a jobs-based EcoDistrict has created the concept of the CMD as a hub for local, mid-sized, food-based manufacturers.[6]

6. Center for Neighborhood Technology, "Chicago's Central Manufacturing District: The Past and Future of Urban Manufacturing," May 2016. http://www.cnt.org/sites/default/files/publications/Chicago%27sCentralManufacturingDistrict.pdf

Photo: darius norvilas, Flickr/Creative Commons

COMPETITIVENESS

In a competitive marketplace, producers can differentiate themselves and attract customers by highlighting benefits, such as production powered by renewable energy or a net zero carbon footprint. An urban manufacturing facility can strengthen a local brand, and on-site sales or factory tours can increase community affinity for a product.

MEETING POLICY REQUIREMENTS

An Industrial EcoDistrict can help manufactures meet policy requirements for resource use and environmental impact. In areas with scarce water, poor air quality, or other challenges, new manufactures may be facing strict efficiency and impact policies. A facility with infrastructure built to lower their impact can be a major selling point over another site with traditional infrastructure.

When sketching out the full potential of an Industrial EcoDistrict the details of benefits to be considered will vary by technology. For example, the NY Prize—a Microgrid design competition in New York State—provides a cost/benefit spreadsheet for applicants that includes the following quantified benefits:[7]

- Reduction in Generating Costs
- Fuel Savings from CHP
- Generation Capacity Cost Savings
- Distribution Capacity Cost Savings
- Reliability Improvements
- Power Quality Improvements
- Avoided Emissions Allowance Costs
- Avoided Emissions Damages
- Major Power Outage Benefits

Quantifying the benefits for each improvement over infrastructure as usual is essential to making the case to investors and users that a change in practice is worthwhile in terms of the bottom line.

7. New York State Energy Research & Development Agency, "New York Prize Cost Benefit Analysis Spreadsheet," January 2015. https://www.nyserda.ny.gov/-/media/NYPrize/files/Cost-Benefit-Analysis-Spreadsheet.xlsm

BEST PRACTICES

ENERGY

District-scale energy solutions allow for efficiencies and innovations beyond what is achievable at the individual-building level. With multiple customers, and potentially different load shapes, energy demand at the district-scale can create opportunities for economies of scale.

RENEWABLES AND STORAGE

WHAT IT IS

Renewable energy—e.g. photovoltaic (PV) solar electricity, wind power, solar thermal, geothermal, sustainable biomass—has come a long way from its early days. With prices for solar and wind now cost-competitive to fossil fuel generation at some scales and with battery storage more effective and affordable, on-site renewables are regularly being designed into buildings. At the district-scale, the potential for renewables is even greater.

Most renewable sources do not provide energy 24-hours a day, so renewable systems need to include energy storage technologies, backup power, and/or a connection to the larger electricity grid. Energy storage can include batteries, compressed air, hydro, and flywheels, as well as technologies that store thermal energy.

WHY DO IT

Reliability, energy independence, and a low carbon footprint may be the foremost reasons to choose renewables, but there are other reasons as well. A PV system requires much less maintenance than a fossil fuel turbine. The cost competitiveness of modern renewables make them a smart economic choice for many applications; although there may be a high upfront capital cost, investment in renewables can protect against future price increases of natural gas or grid electricity. Diesel generators are a conventional on-site backup solution, but have air pollution and climate change impacts and may be subject to regulations that restrict their use to emergencies only, challenges that cleaner energy generation and storage options do not face.

WHAT IT COSTS

Renewable energy costs have dropped dramatically in recent years and are becoming competitive with fossil fuel energy:[8]

- 2016 estimates for PV costs are at about $2 million per MW. (For context, a large university campus might have a peak demand of 40-60 MW.)
- Large commercial-scale wind turbines have similar upfront costs at $2.3 million per MW, but an on-site wind system for an urban district would likely be more expensive–small turbines cost in the range of $6 million per MW. Wind also has higher operations and maintenance costs than solar.
- A biomass-fueled combined heat and power (CHP) installation can cost nearly $6 million per MW, but such a system would also provide heat or steam to a facility, increasing cost effectiveness.
- A 2015 study of energy storage options for commercial and industrial applications found a range of capital costs starting at $310 per kWh for zinc batteries and ranging up to $2,011 per kWh at the highest end for lead-acid batteries with lithium-ion, flow, and sodium batteries lining up in between. Energy storage prices have been falling in recent years and are expected to continue to decrease. Moreover, the use of storage systems for multiple purposes can improve their economics.[9]

8. National Renewable Energy Laboratory, "Distributed Generation Renewable Energy Estimate of Costs," Updated February 2016. http://www.nrel.gov/analysis/tech_lcoe_re_cost_est.html
9. Rocky Mountain Institute, "The Economics of Battery Energy Storage," 2015. http://www.rmi.org/ELECTRICITY_BATTERY_VALUE

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Photo: Jenni Konrad, Flickr/Creative Commons

DISTRICT ENERGY

WHAT IT IS

District energy is a system that provides heating and cooling to a set of buildings, such as through steam and chilled water.

One of the largest district energy installations in the U.S. is in St. Paul, MN. It provides heating, cooling, and electricity to downtown buildings. The system currently serves nearly 300 residential and 200 non-residential buildings with heat.[10]

WHY DO IT

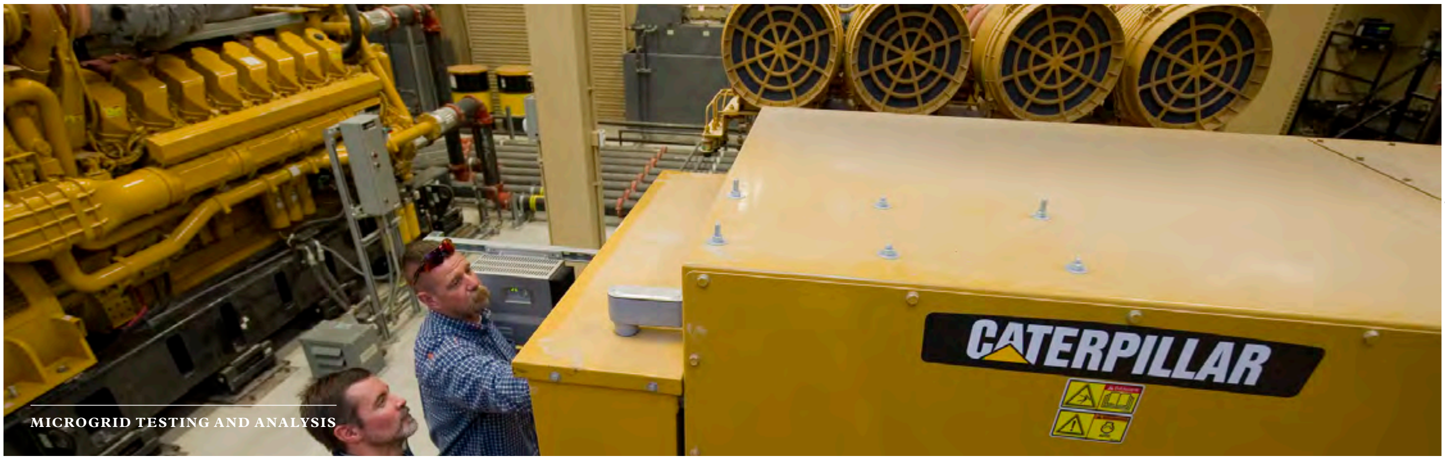
District energy can be very cost effective and can greatly reduce the environmental footprint of heating and cooling buildings, especially when paired with technologies like renewable biomass CHP generation. The technology is not new, but can be made extremely efficient with new generation and management systems. Fuel price trends along with interest in reliable, low-carbon heating sources have revived interest in district energy, especially in cold weather climates. Using the "waste" heat of electricity generation to heat and cool buildings greatly improves carbon and energy efficiency while mitigating heat pollution from power plants. The technology is widely used in Europe, accounting for around 12% of European electricity production.[11]

WHAT IT COSTS

The cost data for district energy are not widely published, but a few case studies give a sense of the scale of the upfront capital investment The Veolia district energy system in Boston and Cambridge, MA has 256 MW in CHP capacity and required $112 million investment—for an investment of $0.4 million per MW. It also provides what it brands as "green steam" thermal energy to 250 customers, so its overall cost per unit of energy provided is even lower. The costs of this project may not be indicative of others, because it involves the extension of pipes from an existing asset: the Kendell Cogeneration Station. Building on an existing asset can provide significant savings and projects starting from scratch may cost more.

However, the Boston example may be applicable in many places, as there are many aging and outdated CHP assets awaiting modernization in cities around the U.S. The U.S. Department of Energy's CHP database includes facilities that were built back in the 1930's.[12] There are other assets that have likely been mothballed—a look at CHP facilities in the U.S. EPA's eGRID database shows 110 plants totaling 8,100 MW in nameplate capacity that produced no heat or electricity in 2012. Some old or mothballed CHP facilities are suitable to retrofit to a new, green district energy system, but not all may be.[13]

10. Nina Axelson, "Building Community Energy in St. Paul," *District Energy*, Q2 2016. http://www.districtenergy.com/wp-content/uploads/2016/04/District-Energy-magazine-cover-story-Q2-2016.pdf
11. COGEN Europe, The European Association for the Promotion of Cogeneration, "Cogeneration in Europe: A brief analysis of the latest Eurostat data," 2015. http://www.districtenergy.org/assets/Whitepapers/Cogeneration-in-Europe-A-brief-analysis-of-the-latest-Eurostat-data-2010-2015.pdf
12. U.S. Department of Energy, "Combined Heat and Power Installation Database," Accessed September 2016. https://doe.icfwebservices.com/chpdb/
13. U.S. Environmental Protection Agency, "Emissions & Generation Resource Integrated Database (eGRID)," Accessed September 2016. https://www.epa.gov/energy/egrid



MICROGRID TESTING AND ANALYSIS

Photo: Idaho National Laboratory, Flickr/Creative Commons

MICROGRIDS

WHAT IT IS

A microgrid, as the name implies, is an electrical grid on a smaller scale. It is typically a set of interconnected electrical users, controllers, and power source(s). A microgrid may also include a back-up power source, such as a bank of batteries or a diesel generator.

WHY DO IT

As an alternative to the hub-and-spoke model that powers most buildings off of a large central generation plant, a microgrid offers several advantages—reliability, efficiency, power quality, independence, and sustainability. While usually still interconnected to the larger electrical grid so that electricity can be purchased and sold as needed, some microgrids can be "islanded" in extreme events to keep the lights on in an emergency. This emergency function has made microgrids very attractive to hospitals and military installations. The massive power outages caused by Hurricane Sandy in 2012 brought the need for electrical reliability home to many, and programs in states like New York and Connecticut are expanding the adoption of microgrids for other types of users, such as neighborhoods, schools, and airports.

The efficiency gains of a microgrid come from reducing transmission losses by placing power generation closer to consumption, as well as the ability to more finely manage the system's supply and demand. Additional efficiency gains can be had if microgrid installation includes enhanced facility efficiency improvements.

As energy infrastructure ages or becomes overburdened due to growth of demand, microgrids can avoid expensive system replacement.

Many current microgrids are making use of natural gas or CHP, but non-fossil fuel solutions exist: St. Paul now has a biomass-fueled CHP plant in its district energy system.[14] Methane from anaerobic digestion is another fuel that might be particularly applicable to manufacturing-based EcoDistricts with food producers.

WHAT IT COSTS

The costs of microgrids are extremely variable depending on the size of the system, the generation and storage components, and more. We reviewed ten case studies of microgrid systems around the U.S. and found upfront capital costs for the systems averaged $3.2 million per MW.

The case studies ranged from $1 million per MW at the University of Massachusetts Worcester Medical Center's microgrid, which includes a 17.5 MW natural gas CHP system, to $9 million per MW for a 13.4 MW CHP microgrid system at New York University. Such CHP systems also provide steam heat and sometimes chilled water to the campus so, if the value of the heat is included, the upfront cost per unit of energy would be lower.[15]

14. Nina Axelson, "Building Community Energy in St. Paul," *District Energy*, Q2 2016. http://www.districtenergy.com/wp-content/uploads/2016/04/District-Energy-magazine-cover-story-Q2-2016.pdf

15. Pace Law School, Pace Energy and Climate Center and International District Energy Association, "Microgrids & District Energy: Pathways to Sustainable Urban Development, Supplemental Material: Case Studies," 2015 http://energy.pace.edu/sites/default/files/publications/USDN%20White%20Paper%20-%20Case%20Studies.pdf

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ENERGY EFFICIENCY AND DEMAND MANAGEMENT

WHAT IT IS

Energy efficiency and demand reduction remain the workhorse of any sustainable system. Ranging from sealing old ducts and windows to replacing outdated refrigeration, updating machinery and motors, and installing smart lighting systems, there are many proven, cost-effective technologies and system changes to lower the energy demand of buildings and manufacturing systems. With effective efficiency and demand reduction some buildings are now achieving "net zero" energy use—that is they generate as much energy as they use. Efficiency and demand management are not just a one-time activity. Energy management systems and periodic reassessment can help ensure that savings stay locked in and additional opportunities to cut energy use are regularly identified.

WHY DO IT

Reducing energy use can be critical in the manufacturing sector where energy may be 10% of production costs.[16] Reducing demand can also reduce the investment needed on the supply side—generation, backup, HVAC, etc. The payback for energy efficiency remains quite attractive. Whereas a 20% energy savings was seen as a reasonable expectation for a renovation just a few years ago, installations are now seeing even greater savings with new smart systems and improved technologies. Facilities doing a massive remodel or building from the ground up can achieve additional savings by designing for efficiency using principles such as daylighting and passive solar and ventilation. Savings of 50% or even 75% have been achieved with such "deep" energy retrofits.

For energy used in the manufacturing process, engineering a production system to lower peak demand and ensure efficiency is critical. Co-locating heat producing processes with heat users, for example, can bring savings to both. Ice storage systems that use energy off-peak at night to provide daytime cooling is another example of a load-shaping technology that can provide significant savings. The U.S. Department of Energy maintains a database of

Photo: trentsd, Flickr/Creative Commons

large manufacturing plants that have undergone energy assessments that may provide useful contact information of industry experts.[17]

WHAT IT COSTS

The cost of an energy efficiency or load shaping investment will vary greatly with the actions implemented, but can have significant payback. By one estimate, an average of 6% of energy use can be saved without capital cost through behavior change and process changes alone.[18]

The American Council for an Energy Efficient Economy has found that energy efficiency is the least expensive energy source –at 2.8 cents per kWh and 35 cents per therm for utility energy efficiency programs.[19]

Typically a facility will get an assessment and then figure out which strategies will provide an acceptable return on investment (ROI) as compared to energy costs. Investments with ROIs of 3 year or less can include lighting, compressed air systems, motors, and pumps.[20] A ROI calculation can become even more attractive if one can size a smaller renewable or energy storage installation because of lower energy use or peak demand.

Unfortunately, even with a strong ROI, the capital cost can be a barrier when it comes time to purchase equipment with higher efficiency ratings or make efficiency improvements. For this reason it is important to set clear efficiency goals and build broad commitment to them among decision makers. Federal, state and utility incentives and financing are often available for efficiency upgrades, which can help offset upfront capital costs.

16. Siemens, "Energy Efficient Production," Accessed May 2017. http://www.industry.siemens.com/topics/global/en/energy-efficient-production/pages/Default.aspx
17. U.S. Department of Energy, Energy Efficiency and Renewable Energy, Advanced Manufacturing Office, "Large Plant Assessments," Accessed December 2016. http://www1.eere.energy.gov/manufacturing/assessment/default.aspx
18. National Association of Manufacturers, "Efficiency and Innovation In U.S. Manufacturing Energy Use," 2014. http://energy.gov/sites/prod/files/2014/05/f15/energy-nam.pdf
19. American Council for an Energy Efficient Economy, "The Best Value for America's Energy Dollar: A National Review of the Cost of Utility Energy Efficiency Programs," 2014. http://aceee.org/press/2014/03/new-report-finds-energy-efficiency-a
20. National Association of Manufacturers, "Efficiency and Innovation In U.S. Manufacturing Energy Use," 2014. http://energy.gov/sites/prod/files/2014/05/f15/energy-nam.pdf

WATER

As one of the prime resources used in industrial buildings, water efficiency technologies can contribute significantly to a producer's bottom line. This is especially important for resiliency in drought-prone areas where climate change may contribute to greater water scarcity and price volatility in coming years. According to the Alliance for Water Efficiency, the steps for saving water in manufacturing by order of least to greatest investment are:

1. Adjusting the flow of water
2. Modifying the equipment or installing water saving devices
3. Replacing existing equipment with more water-efficient equipment
4. Water treatment, recycling, and reuse
5. Changing to a waterless process[21]

WATER EFFICIENCY AND DEMAND REDUCTION

For greatest impact and least expense, energy and water systems should be designed or retrofitted at the same time. Water efficiency has many of the same considerations discussed in the energy efficiency strategy. Costs are similarly dependent on the level of efficiency or demand reduction sought.

WATER REUSE

WHAT IT IS

Industrial water reuse has always existed, such as in closed-loop systems. Recently more technologies are being added to the reuse portfolio. Typically identified by purple colored pipes, graywater, or "nonpotable water" reuse systems take lightly-used water, such as from sinks, bottle washing, or produce cleaning and recycle it within a site to uses like toilet flushing, heating system boilers, or cooling systems. Other industrial water reuse systems involve more onsite treatment. Some designs look at making use of treated municipal wastewater for cooling and other non-potable applications where a lower-level of treatment can be utilized.

Photo: Oregon Department of Transportation, Flickr/Creative Commons

WHY DO IT

A water reuse system can reduce a site's water demand and costs significantly. Rather than use treated, drinkable water for industrial processes, the reuse of water on-site reduces demand for the increasingly scarce fresh water and improves the resiliency of a community to droughts. For industries that must pre-treat water before discharging it into the sewer system, treatment is already occurring on-site and updating to a modern system that treats to a level that enables onsite reuse can make even more economic sense. System-wide, water demand reduction also cuts the energy used to treat and pump water.

As an example, Frito-Lay instituted a water reuse system in its Casa Grande, Arizona chip plant, where it saves 100 million gallons of water per year by treating and reusing the water in their potato washing and other systems. This allowed for the removal of old wastewater storage and the reuse of the land for a 5MW solar power installation.[22]

WHAT IT COSTS

A study of capital costs for non-potable water reuse systems, focusing mainly on municipal systems, found a range of capital costs of $0.10 to $1.63 per thousand gallons of capacity when amortized over 20 years. Energy and other operations and maintenance (O&M) costs can be significant for water reuse systems, so, including O&M, the study found a range of costs of $0.15 to $2.65 per thousand gallons of capacity amortized over 20 years.[23] Another recent study found costs to average $2.88 per thousand gallons across 14 projects.[24] Costs will be greatly impacted by the level of treatment required.

21. Alliance for Water Efficiency, "Manufacturing Introduction," Accessed May 2017. http://www.allianceforwaterefficiency.org/Manufacturing_Introduction.aspx
22. Al Goodman, CDM Smith, "Frito-Lay Process Water Recovery Treatment Plant, Casa Grande, Arizona," 2012. http://www.reclaimedwater.net/data/files/152.pdf and Ryan Randazzo, "Frito's Casa Grande Facility Uses Technology to Harness Resources, Slash Costs," *The Arizona Republic*, October 14, 2011. http://archive.azcentral.com/community/pinal/articles/2011/10/14/20111014casa-grande-frito-lay-plant-power-water-costs.html
23. National Research Council, "Water Reuse: Potential for Expanding the Nation's Water Supply through Reuse of Municipal Wastewater," Table 9.3, 2012. http://www.nap.edu/read/13303/chapter/11#156
24. Joan Oppenheimer et al, "Drivers, Successes, Challenges and Opportunities for Onsite Industrial Water Reuse: a Path Forward for Collaboration and Growth" WateReuse-13-04,2015. https://watereuse.org/wp-content/uploads/2015/03/OnsiteWaterReuseWebcast.pdf

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INDUSTRY CITY Brooklyn, NY

Industry City was a monumental intermodal complex built around the turn of the last century. With six million square feet located in Sunset Park, Brooklyn, Industry City housed many firms (including Topps Baseball Cards) during New York's manufacturing heyday, before falling on hard times. Today, Industry City is housing a new generation of urban makers, an innovation lab, and workforce development along with food, art, and retail that attracts residents from the neighborhood and beyond. While not an EcoDistrict, Industry City's transit access, mix of activities, and building reuse represent some of the building blocks of sustainable district-scale manufacturing innovation.

Photo: Dave Pinter, Flickr/Creative Commons

TRANSPORTATION

Industrial facilities face a broad array of transportation challenges: employees must come and go, along with raw materials and supplies, finished product, and waste. An Industrial EcoDistrict can help address all of these challenges with smart planning and close, ongoing management of the on-site transportation needs.

URBAN, TRANSIT-SERVED LOCATIONS

WHAT IT IS

Urban, transit-served locations are ideal for Industrial EcoDistricts, because they can put producers in proximity to suppliers and employees.

WHY DO IT

The commutes of workers are an important component in the environmental footprint and costs of an industrial facility. Industrial jobs that are located far away from a region's housing centers and transit hubs place a burden on employees in terms of cost and time, and can affect productivity. Urban, transit-served locations, in contrast, increase the accessibility of jobs and broaden the pool of potential employees, which can provide employers with a higher quality workforce. CNT's AllTransit Database shows the number of workers that can get to any work location with a 30 minute transit trip. An employer located in west suburban Elgin, IL has just 43,032 workers who can reach their site by a transit trip of 30 minutes or less. In contrast, an employer in Chicago's 60609 zip code—an area including Back of the Yards that has historically been home to many manufacturers—has 239,371 workers who can reach their site with a transit trip of 30 minutes or less.[25]

In addition to access by employees, a central location can give a producer access to suppliers, partners, distributors, and even opportunities to connect direct to consumers. If the facility is producing a consumer products an on-site retail outlet and/or factory tours can build a customer base and increase brand recognition and loyalty. Local pride in a product "made in our town" can be a great selling point as well.

25. Center for Neighborhood Technology, "AllTransit," Accessed May 2017. http://alltransit.cnt.org/metrics/?addr=elgin%2C+il

WHAT IT COSTS

On the face of it, industrial spaces in cities and first ring suburbs will generally have higher costs per square foot than exurban areas, but these costs should be considered against other locational benefits. For example, in the Los Angeles area in late 2015 industrial rents ran $7-$8 per square foot, but in the Inland Empire region 60 miles away industrial rents were $5-$6 per square foot.[26] This will vary by market, but in general urban industrial spaces face high demand.[27] Industrial space in urban neighborhoods may also be hard to find, depending on the local market. Too often older industrial spaces are being converted to residential and commercial uses, which leaves fewer opportunities for manufacturing and its jobs to return to efficient urban locations.[28] These competing uses also drive up costs. Many cities have used zoning rules to preserve industrial space, but enforcement issues and transformation to other zoned uses has been a problem. In San Francisco the land zoned for industrial uses has fallen to just 6.5% of the city;[29] an effort is underway to preserve industrial production in the city by allowing the development of facilities that include both industrial and office spaces, so that the companies renting offices help cross-subsidize costs and keep production space costs lower. A similar effort is being tried in New York.[30]

GOODS TRANSPORTATION & LOGISTICS

WHAT IT IS

Transportation of raw materials and finished products is an important piece of infrastructure for industrial buildings.

WHY DO IT

Rail transportation from manufacturing sites is generally seen as a dirty relic, but in fact manufacturing and freight facilities can play an anchoring function for local and regional economies. Current technologies and management systems, including electrification of intermodal yards, can serve to improve the efficiency of rail systems while greatly reducing their environmental impact. Modernizing freight logistics facilities can also have the impact of freeing up land as shipping containers can be efficiently stacked and moved through the facility in a fraction of the time previously required. As a result manufacturing can be co-located with shipping facilities, lowering the cost of doing business.

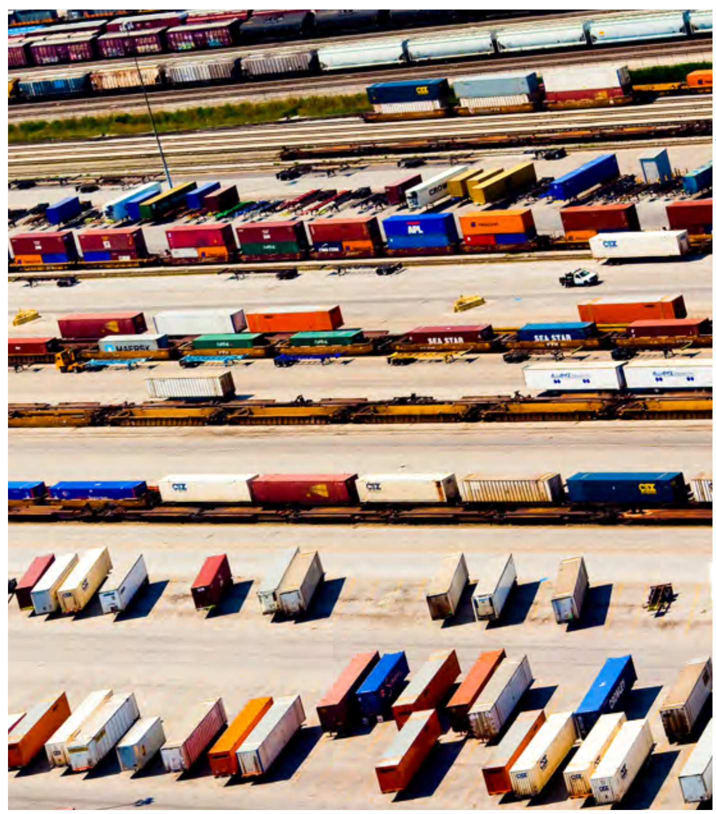

Photo: Thomas Hawk, Flickr/Creative Commons

26. CBRE, "U.S. Industrial & Logistics MarketView." Q4 2015.
27. Mike Hockett, "E-Commerce Driving Demand For Smaller, Urban Distribution Centers," *Industrial Distribution*, September 2, 2015. https://www.inddist.com/blog/2015/09/e-commerce-driving-demand-smaller-urban-distribution-centers
28. Candace Jackson, "Converting Commercial Properties into Homes," *Wall Street Journal*, May 29, 2014. http://www.wsj.com/articles/converting-commercial-properties-into-homes-1401401893?mg=id-wsj
29. Karen Chapple, "Industrial Land and Jobs Study," Table 1, September 2016. http://abag.ca.gov/abag/events/agendas/r100516a-Item%206%20Attach%2001Industrial%20Land%20and%20Jobs%20study.pdf
30. Pratt Center for Community Development, "Creating an Innovative Mix: What We Can Learn from San Francisco," February 2016. http://prattcenter.net/sites/default/files/25_kent_policy_brief_final_0.pdf

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WHAT IT COSTS

The cost impact of improving the efficiency of transportation and logistics can be significant. As shown in Figure 1, large manufacturers pay as little as 3 percent of sales for shipping, while the smallest firms pay as much as 14 percent, well above the national average of 6-9 percent.[31] This high cost of transportation takes away from the bottom line and puts small firms at a competitive disadvantage.

A system relying exclusively on trucking can be costly and inefficient. Rail shipping has lower emissions and lower costs; however large (Class I) railroads do not ship freight in units of less than a train carload. Finding innovative ways to move smaller quantities of goods more cheaply, such as through a freight car sharing or freight consolidation program for small manufacturers, could help small and mid-sized firms succeed. Experiments with alternative services to lower shipping costs include Cargomatic.com and Zipments.com, both in effect "truck sharing" services.[32] More needs to be done to bring such services to scale cost-effectively for the rail industry. In shared or co-located facilities, coordinated shipment of bulk inputs can be another cost and energy saving measure.

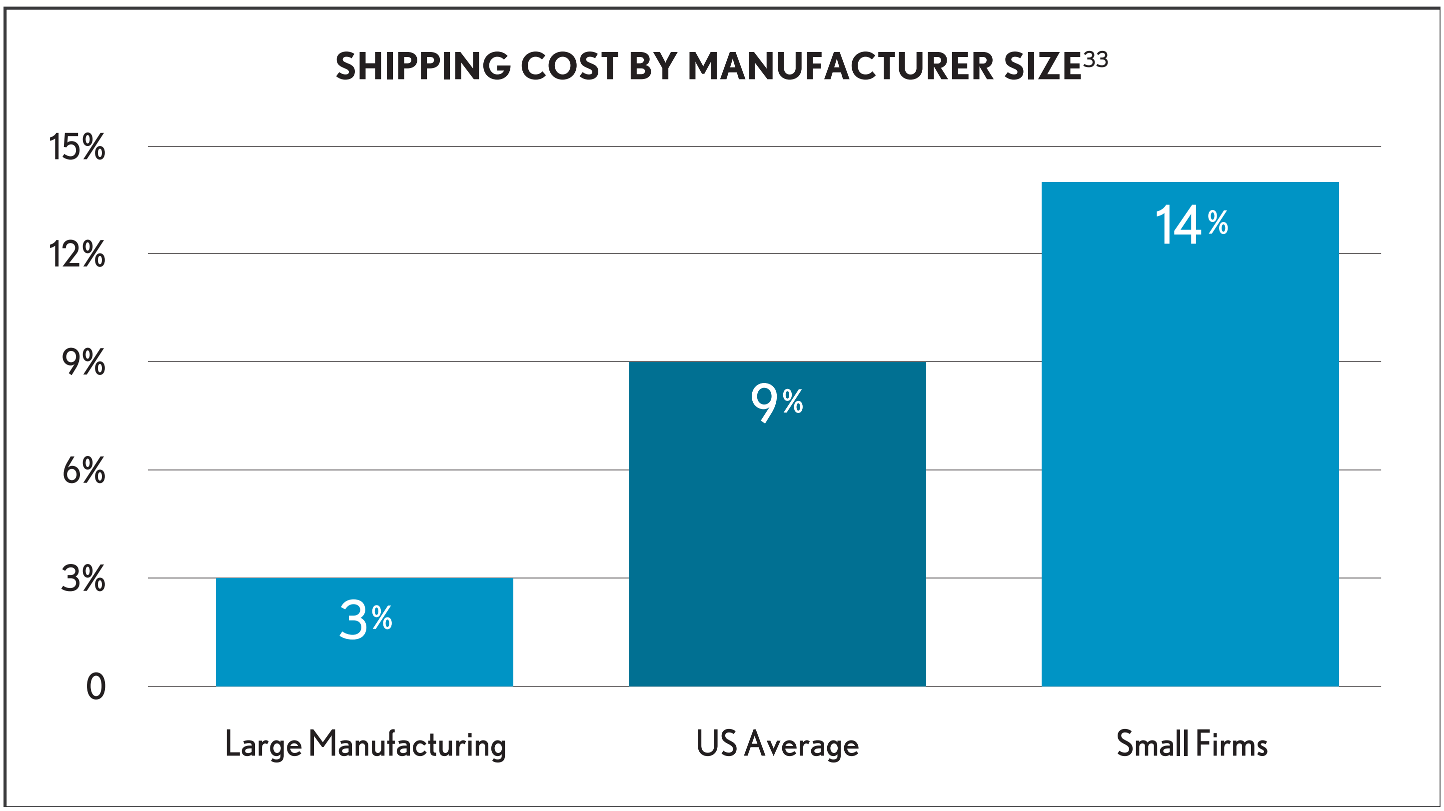

FIGURE 1
Shipping Cost by Manufacturer Size

31. CNT analysis of Transportation Satellite Accounts from U.S. Department of Transportation, Bureau of Transportation Statistics and U.S. Department of Commerce, Bureau of Economic Analysis.
32. Logistics Trends, "Seven Companies that Will Change the Face of Logistics," December 7, 2015. https://logisticstrends.com/seven-companies-that-will-change-the-face-of-logistics/
33. CNT analysis of Transportation Satellite Accounts from U.S. Department of Transportation, Bureau of Transportation Statistics and U.S. Department of Commerce, Bureau of Economic Analysis.

WASTE SYSTEMS

WHAT IT IS

Industrial facilities have historically been major producers of waste, but that is changing. Manufacturers are using supply chain management, quality control, and smart design to cut waste, as well as finding innovative uses for "waste products" that were previously considered worthless –or an additional cost of production. In the 1990's the idea of "Eco-Industrial Parks" wherein manufacturers would be co-located to be able to use each other's waste outputs as inputs gained popularity. This still happens, and can be beneficial, but in practice, firms are more often doing such waste utilization internally.

WHY DO IT

Waste disposal can be costly and has significant environmental impacts. Making use of the resources in the waste stream, including building materials, metals, recyclable plastics, and compostables is more job-intensive and sustainable than landfilling. The 2011 Tellus Institute report, "More Jobs, Less Pollution," projects that if 75% of the municipal solid waste and construction and demolition debris in the U.S. were diverted by 2030 in the U.S. it would create more than a million jobs over business as usual, while reducing greenhouse gas emissions and other pollutants.[34] That estimate does not include industrial waste, but gives a sense of the scale of the opportunity.

Improving waste systems can be beneficial on site as well. For example, waste oils and cooking grease can be hazardous or cause drainage problems if handled improperly. But if recycled into biofuel they can reduce greenhouse gas emissions and even generate a small financial return. Anaerobic digestion of waste organic material and conversion into heat and power is another on-site solution that is gaining popularity.

Photo: Zeke Franco, Flickr/Creative Commons

WHAT IT COSTS

Reducing waste and improving waste systems can require investment and ongoing operating expense, but it can also reduce waste disposal costs and reduce liability. In the best cases waste reuse cuts the need for costly inputs or generates energy and offsets electricity purchases. The economics will vary by place and time. In some parts of the country recyclable materials have significant value, while in others one must pay to have materials recycled. A case study of waste diversion during renovation of Clarke, an appliance distributor in Massachusetts, showed that recycling over 2,200 tons of debris cost nearly $8,000 but avoided $267,000 in disposal costs.[35] Anaerobic digesters can cost $95,000 to $300,000 and up, and do have annual operational costs, but could save tens of thousands of dollars in energy purchases and waste disposal fees each year. A U.S. Environmental Protection Agency study of anaerobic digestion on several farms found benefits ranging from $16,000 to $55,000 per year.[36]

34. Tellus Institute and Sound Resource Management, "More Jobs, Less Pollution: Growing the Recycling Economy in the U.S.," 2011. https://www.nrdc.org/sites/default/files/glo_11111401a.pdf
35. Massachusetts Department of Environmental Protection, "Case Study: Construction and Demolition Waste Reduction," 2004. http://www.mass.gov/eea/docs/dep/recycle/reduce/06-thru-l/cdclarke.pdf
36. Mark A. Moser, et al, "Benefits, Costs and Operating Experience at Seven New Agricultural Anaerobic Digesters," 2010. https://www.epa.gov/sites/production/files/2014-12/documents/lib-ben.pdf

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GETTING IT DONE

SITE SELECTION

Any site can be home to cutting-edge sustainable infrastructure innovations. But it will be easier and more cost-effective at some more location efficient sites, rather than others. When selecting sites for an industrial facility consider the following criteria:

UNDERVALUED ASSETS: There are many small CHP facilities sitting unused in cities, because they were idled for reasons such as: they were not cost effective in the energy market at the time; or the owner was no longer interested in running an energy facility. This kind of undervalued asset can be a major building block for a district-scale infrastructure system.

CLUSTERING: A cluster of facilities with complementary resource needs is also offers an opportunity for an Industrial EcoDistrict. Many of the finalists for the NY Prize—a state-funded competitive planning an implementation grant for microgrids—are clusters of hospitals or other emergency services that will benefit from the resilience and disaster preparedness benefits of improved electricity reliability.[37]

TRANSPORTATION ACCESS: Access to transportation alternatives is important for workers, customers, and goods movement. For many decades industrial parks have been sited near freeway interchanges, but the market is now increasingly acknowledging the value of urban rail- and public transit-accessible locations.

GOVERNANCE AND ENGAGEMENT

The range of actors involved in a successful Industrial EcoDistrict can be large. Figure 2 shows who some of these groups can be. Choosing or creating the right entities for governance, asset ownership, management, and billing is essential. Some EcoDistricts have found it useful to create a new legal entity for EcoDistrict management. Financing should be a consideration in EcoDistrict governance design, as public, private, and nonprofit entities will have access to difference financing types.

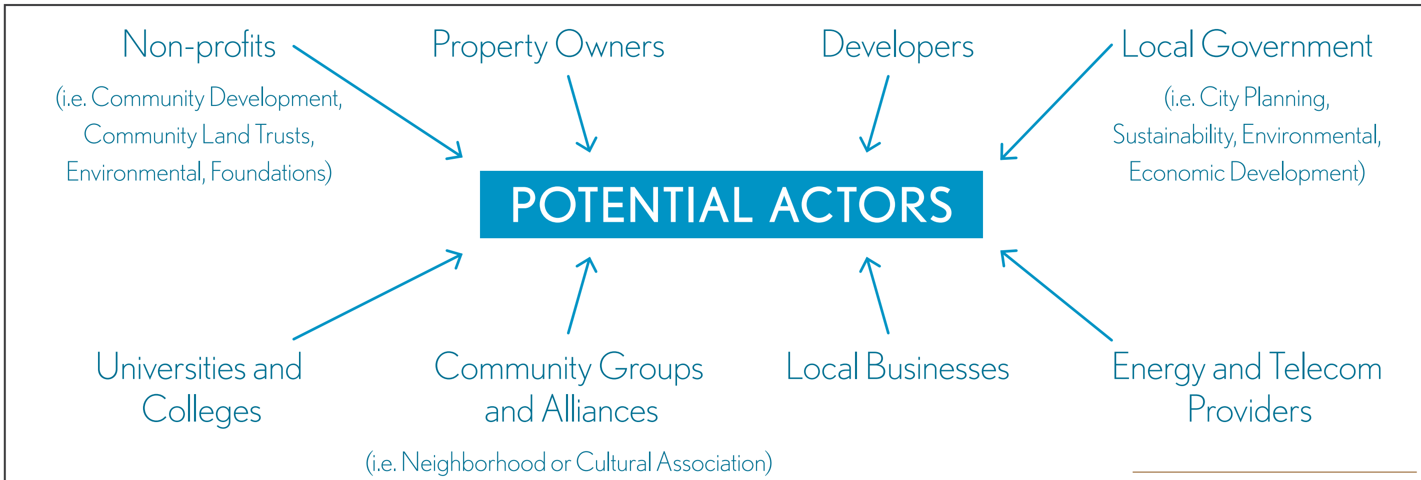

FIGURE 2
Potential Industrial EcoDistrict Actors

37. Elisa Wood, "Meet the Microgrid Project Winners Selected in Stage 2 of the NY Prize," *Microgrid Knowledge*, March 24, 2017. https://microgridknowledge.com/microgrid-project-list-ny-prize/

Photo: www.SeniorLiving.org, Flickr/Creative Commons

Engagement is also critical to Industrial EcoDistrict success. Internally, the people working each day in the businesses will play a big role in making sure that the full potential of the EcoDistrict is realized. Proper training is necessary to ensure equipment is being used efficiently, that it is shut down when not needed, and that regular maintenance keeps everything running as designed. A two-way conversation with the people involved with day-to-day EcoDistrict activities is also the best way to continue improving the systems over time. Externally, engagement surrounding neighborhoods and the city can help the EcoDistrict grow, as well as raise its profile and expand the reach of its learnings and innovations.

FINANCING

One cannot yet go to the corner bank and receive financing for the innovative infrastructure involved in an EcoDistrict. Where funding exists, it is often siloed by infrastructure type—federal funds for transportation, water, and energy are all run through different agencies. Government grants are the largest microgrid funding sources today, according to Navigant Consulting, in part because microgrids have been R&D and demonstration projects. Going forward, government grants or loans will likely continue to play a role in the more unpredictable up-front stage of microgrid development, or for particular features that improve community resiliency, while over time private capital will become more comfortable with the risks and returns of microgrid operations just as they have with renewable installations.[38] There are a number of things that can be done to speed up this process that we discuss in in “How the Public Sector Can Help” below.

The exact costs of integrated infrastructure will, of course, vary greatly with the application, the level of service, the technologies selected, and a myriad of other factors. An individual facility’s water reuse project could cost tens of thousands of dollars, while a multi-building-scale system for water reuse, district energy, transportation alternatives, and more will require upfront capital in the range of millions to even hundreds of millions of dollars for a large set of significant interventions. For example, a “Deep Green” EcoDistrict infrastructure scenario created for a Phoenix neighborhood was estimated to cost $81 million.[39]

As with any innovative technology, one can expect the costs to decline over time as systems become more turn-key and the number of installations increases. Furthermore, if local energy prices are expected to increase, the project may have more capacity to pay back capital investments later in the system life.

38. Jonathan Strahl, Emily Paris, and Laura Vogel, Navigant Consulting, “The Bankable Microgrid: Strategies for Financing On-Site Power Generation,” 2015.

39. Curt Upton, Hazel Borys, and Scott Bernstein, “Beyond TIF: a Finance Model for the Phoenix Gateway and Beyond,” EcoDistrict Summit Presentation, September 14, 2016. http://www.summit.ecodistricts.org/wp-content/uploads/2017/03/1-Beyond-TIF.pdf

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Looking at best practices and innovation examples from around the U.S. and beyond, we have assembled a list of some of the financing options that could be adapted to help bring sustainable, 21st century infrastructure to scale. Broadly, these strategies include bringing new capital into the market, driving down risk, standardizing transactions, capturing future value creation, attracting patient capital, quantifying non-financial returns, and creating new links between investment and benefit streams. Each of the strategies listed below is described further in a separate CNT white paper. They will likely need to change from their current form to fit infrastructure needs, but we encourage those interested in Industrial EcoDistricts to look at the innovations in financing occurring in other sectors as potential models.

- **MINI BONDS:** Compared to traditional municipal or corporate bonds, mini-bonds are smaller and more consumer-focused. They can therefore serve as a sort-of "crowdfunding" mechanism for local infrastructure, generating interest and support for a project as well as funds.
- **GREEN BONDS:** Green bonds are debt-financing for projects that have positive environmental benefits. The differentiation of green bonds in the bond marketplace is primarily its appeal to investors with environmental interests or screens.
- **SOCIAL IMPACT BONDS:** The idea behind social impact bonds is to generate capital for social programs that are creating net economic benefits for governments, but for which there has not been a value capture mechanism in place. An agreement with a third party that includes a pay-for-performance element can capture savings for program expansion. Washington, DC adapted the pay-for-performance model with its Environmental Impact Bond. The city will use investment funds to implement green infrastructure to avoid stormwater runoff.[40]
- **RESILIENCE BONDS:** Resilience bonds are being used for innovative stormwater management and flooding interventions. By creating a link between disaster insurers and project developers, the bonds can capture the savings of reduced stormwater and floodwater damage.
- **TAX INCREMENT FINANCING (TIF):** Tax Increment Financing (TIF) borrows against the future stream of additional tax revenue a project is expected to generate to finance improvements. TIF is a half-century old form of value capture and has been a tool used in many, mainly urban, communities to cover development and infrastructure costs, but its use for sustainable infrastructure is somewhat novel.
- **REVOLVING LOAN FUND (RLF):** For investments that will create a direct financial savings or revenue stream a revolving loan fund can provide an ongoing source of capital. Once the fund is established and lent out, new projects are paid for with funds repaid by borrowers. One significant use of this model for infrastructure is the Clean Water State Revolving Loan Fund, a 30-year-old program that has provided nearly 40,000 loans totaling $120 billion for water infrastructure projects.[41]
- **PUBLIC-PRIVATE PARTNERSHIPS (P3S):** Public-private partnerships allow the public sector to bring in private enterprises to take an active role in a project. P3s enable the sharing of risk and can expand the capital available for a project beyond the government coffers and can be used for one or more project phase—design, build, finance, operate, and/or maintain.[42] When designing a P3 for an infrastructure innovation careful attention must be paid to the risk sharing arrangement so that the public does not take on an undue financial burden if the project underperforms, and careful consideration of the full value of long-term public ownership should be assessed, as there may be aspects to ownership that the community values but the private marketplace does not.
- **IMPACT FEES:** In places where taxes alone do not adequately fund the full range of public services and infrastructure, communities have begun charging impact fees on new developments or redevelopments. The fees are meant to directly pay for the additional demand on city services and infrastructure that the development will generate.[43]

40. U.S. Environmental Protection Agency, "DC Water's Environmental Impact Bond: A First of its Kind," April 2017. https://www.epa.gov/sites/production/files/2017-04/documents/dc_waters_environmental_impact_bond_a_first_of_its_kind_final2.pdf
41. U.S. Environmental Protection Agency, "Clean Water State Revolving Fund (CWSRF)," Accessed May 2017. https://www.epa.gov/cwsrf
42. U.S. Department of Transportation, Federal Highway Administration, "Types of Public-Private Partnerships (P3s)," 2017. https://www.fhwa.dot.gov/ipd/pdfs/fact_sheets/techtools_P3_options.pdf
43. American Planning Association, "APA Policy Guide on Impact Fees," 1997. https://www.planning.org/policy/guides/adopted/impactfees.htm

- **PARKING BENEFIT DISTRICT (PBD):** Communities and private actors have long charged for parking in dense areas. In recent years, thanks to the work of Professor Donald Shoup, the concept of a Parking Benefits District has arisen in which a share of the fees collected for parking are reinvested into the district.[44]

- **PRE-DEVELOPMENT FUND:** The creation of an investment fund aimed directly at the sustainable infrastructure market could match investors with interest in green projects to implementers in need of capital for projects that the traditional marketplace has not yet fully understood. This has been done successfully for Transit Oriented Development in the San Francisco Bay Area with the $50 million Bay Area Transit-Oriented Affordable Housing (TOAH) Fund.[45]

- **PROPERTY ASSESSED CLEAN ENERGY (PACE):** Property Assessed Clean Energy (PACE) financing allows property owners to pay for energy improvements, such as solar energy, through property tax assessments. This is an evolving tool–PACE enabling legislation varies by state, and local governments, including cities and counties, are implementing PACE in different ways, and partnerships with financial institutions can play an important role.[46]

- **CREDIT ENHANCEMENT:** Credit enhancement is a useful way to expand the reach of a program and help borrowers who may not otherwise qualify for cost-effective financing. This can be very important for innovations that are not yet turn-key in the market and which some risk-adversity among traditional sources of capital. Loan loss reserves and loan guarantees are both examples of credit enhancements.[47]

- **INFRASTRUCTURE INVESTMENT FUNDS & INFRASTRUCTURE BANK:** An infrastructure investment fund or an infrastructure bank is a lending program specifically designed for the needs of infrastructure, which may have long construction times and long pay back periods. Connecticut's Green Bank an example of an adaptation of this model, providing financing for green energy and energy efficiency in that state.[48]

Photo: Peggy Wong, Flickr/Creative Commons


Photo: Clean Energy Resource Teams, Flickr/Creative Commons

44. Donald Shoup, *The High Cost of Fee Parking*, 2011. http://shoup.bol.ucla.edu/PrefaceHighCostFreeParking.pdf
45. Bay Area Transit-Oriented Affordable Housing Fund (TOAH), "Bay Area TOAH Fund," Accessed June 2017. http://bayareatod.com/
46. American Council for an Energy Efficient Economy, "Property Assessed Clean Energy (PACE)," Accessed May 2017. http://aceee.org/sector/state-policy/toolkit/pace
47. The State and Local Energy Efficiency Action Network, "Credit Enhancement Overview Guide," January 2014. https://www4.eere.energy.gov/seeaction/system/files/documents/credit_enhancement_guide.pdf

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POLICY

The public sector has a major role to play in helping to catalyze the creation of 21st century, green industrial redevelopment around the country. Below are just a few of the ways.

PRESERVING INDUSTRIAL ZONES: The pressure is on to permit the conversion of manufacturing space in cities to other uses.[49] The transformation of old industrial buildings into loft condos and tech offices has helped revitalize cities in recent decades, but it has also created stiff competition for space if manufacturers want to set up shop in location efficient urban areas. Enabling transformation of areas zoned industrial to these other uses should be carefully weighed against the benefits of preserving urban manufacturing in terms of economic resiliency, quality jobs, and sustainability. The benefits of preserving industrial activity in a city should be fully documented to help make the case for this.

ZONING INNOVATIONS: In recent years, San Francisco has instituted some zoning adjustments to better enable manufacturers to have retail outlets and to allow multiple uses on site. For example, a redevelopment can combine new manufacturing space with office space to help make the development of new manufacturing space economically feasible.[50] One example of this in action is the popular Heath Ceramics factory in San Francisco's Mission District, which is highlighted in a case study in this paper.

HEATH CERAMICS San Francisco, CA

The Heath Ceramics Factory in San Francisco includes a retail outlet, a demonstration kitchen, a Blue Bottle coffee shop, and an art gallery all in the same building with the ceramic tile factory. A new bread bakery and restaurant called Tartine Manufactory opened in part of the space in August 2016. This innovative combination of uses would not have been allowed under many traditional zoning schemes. But some "zoning yoga," as one city staff member called it, allowed the manufacturer to locate in the city economically and serve as a destination for the community.

48. Connecticut Green Bank, "About Us," Accessed May 2017. http://www.ctgreenbank.com/about-us/
49. See, e.g. J.K. Dineen, "Offices Intruding on SF Space Zoned for Industrial Use," *San Francisco Chronicle*, March, 14 2016. http://www.sfchronicle.com/bayarea/article/Offices-intruding-on-SF-space-zoned-for-6889809.php
50. City of San Francisco. Board of Supervisors. Ordinance 71-14. Passed May 13, 2014. http://www.sfbos.org/ftp/uploadedfiles/bdsupvrs/ordinances14/o0071-14.pdf

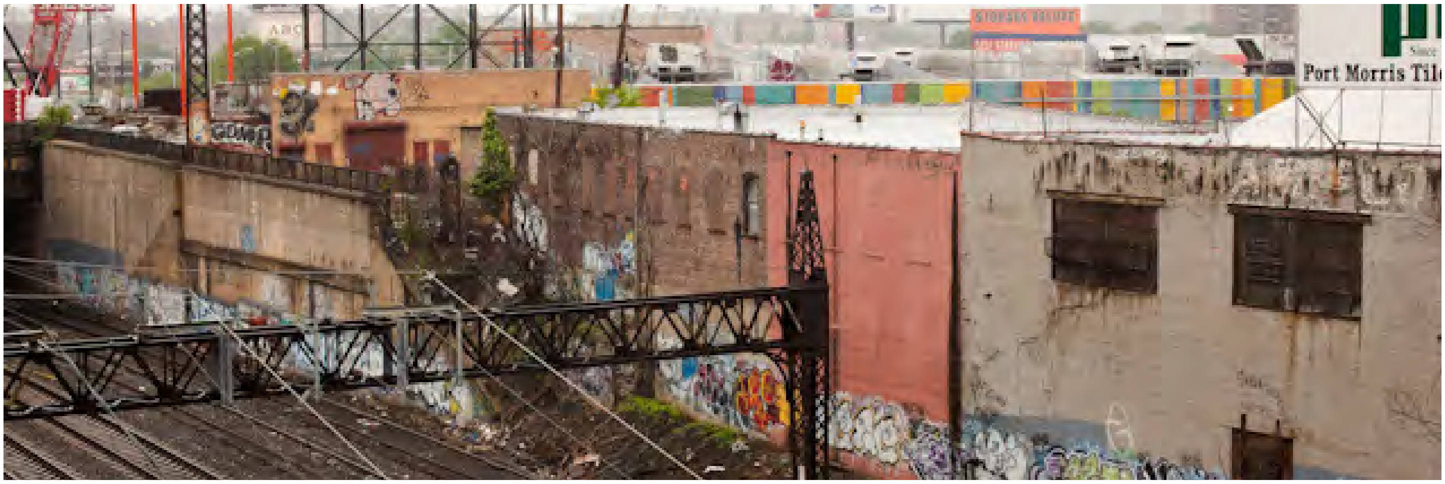

Photo: Atomische * Tom Giebel, Flickr/Creative Commons

REMOVING POLICY BARRIERS: Some of the key innovations available for resource provision and infrastructure today face barriers in local or state policy. Public health policies may limit the reuse of graywater on site. Utility franchise policies may limit the sharing of electricity or heat across organizations or across the public right away. A full assessment of these issues and proposed policy changes where appropriate should be undertaken.[51]

COORDINATION AND FACILITATION: New York City's Economic Development Corporation has played a vital role in the industrial resurgence in that city. Their, "Sunset Park Vision Plan," created a vision and investment strategy for a green industrial district.[52] Other local governments should look to this success and see if a local or regional coordinating entity can be created to showcase the benefits of green industrial reuse over other use types, use performance measures to prioritize green industrial redevelopment and EcoDistricts, help educate and inform about sustainable infrastructure practices, coordinate the disparate entities involved in EcoDistricts, work to identify and remove policy barriers, and assist with financing mechanisms.

PROVIDING STANDARDS: EcoDistricts face additional costs because each deal is a one-off. The implementation of standard contracts for innovative infrastructure would speed up the adoption process and lower costs. Such contracts, for example, have been developed in the solar industry.[53]

DOCUMENTING BENEFITS

The benefits of district-scale integrated infrastructure systems have not been fully identified or valued. This contributes to financing difficulties. Consider, for example, the Hunts Point Food Distribution Center (FDC), which applied for microgrid funding as part of the NY Prize.[54] The facility is the distribution point for produce, meat and fish for a 60 percent of New York City. Electricity reliability for cooling to keep food at safe temperatures is not just a business issue, but a major public health concern as well. Improving resiliency at facilities like that offer benefits beyond the building—an insurance company benefits when backup power allows for continuous refrigeration of expensive medications, a power company benefits when a microgrid with energy storage helps trim peak load use and remove the need for additional capacity investments.

As Anna Chittum from the American Council for an Energy-Efficient Economy states in the 2016 paper, "Valuing Resiliency: How Should We Measure Risk Reduction?":

> "The current piecemeal approach to measuring and addressing risks related to power outages and other failures ensures that the energy system we are building is not maximizing potential system resiliency, reliability, and quality."

51. See e.g. Harvard Law School, Emmet Environmental Policy Clinic, "Massachusetts Microgrids: Overcoming Legal Obstacles," September 2014. http://environment.law.harvard.edu/wp-content/uploads/2015/08/masschusetts-microgrids_overcoming-legal-obstacles.pdf and New York State Energy Research and Development Authority, "Microgrids: An Assessment of the Value, Opportunities and Barriers to Deployment in New York State," Final Report 10-35, September 2010. http://web.mit.edu/cron/project/EESP-Cambridge/microgrid/NYS-Microgrids-Roadmap.pdf
52. New York City's Economic Development Corporation, "Sunset Park Vision Plan," Updated September 12, 2016. https://www.nycedc.com/project/sunset-park-vision-plan
53. Zachary Shahan, "Solar Contract Templates Developed By NREL & Partners," *CleanTechnica*, November 23, 2013. https://cleantechnica.com/2013/11/23/solar-contract-templates-developed-nrel-partners/
54. Elisa Wood, "A Microgrid to Keep New York City's Fresh Food Supply Safe," *Microgrid Knowledge*, August 4, 2016. https://microgridknowledge.com/microgrid-2/

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GATEWAY DISTRICT Phoenix, AZ

Over a multi-year period, the City of Phoenix conducted an exercise that came to be known as Reinvent Phoenix, a kind of comprehensive plan for the city conceived of and centered around a network of transit-oriented station areas. A particular challenge was to identify a way to finance infrastructure in parts of such areas that had never previously supported high-density mixed-use development, as much of the initial light-rail system was built over former freight right-of-way. A multistation area known as the Gateway District is centered on the two stations closest to the Phoenix Sky Harbor International Airport, and includes areas that are residential, commercial and industrial in character. The nature of the challenge was confounded by a state legislative restriction on the use of Tax Increment Financing for area redevelopment, the only state to have such a restriction. A team consisting of Placemakers LLC, the Center for Neighborhood Technology and Crabtree Engineering worked under contract with the firm of DPZ and with the advice of key city and development industry leaders, developed a plan for a Phoenix Gateway District EcoDistrict. The physical plan is to develop the 2-station area TOD, 1.2 x 0.5 miles, according to walkable urbanism principles. The financing plan is based on the concept of an off-balance sheet-based pre-development fund that can acquire land and right of way and fund all necessary infrastructure; in this case the infrastructure is an integrated set of district energy, water, transportation, stormwater management, heat island mitigation and telecommunications assets. The investment estimated on the order of $81 million would be paid back as infill, envisioned as adding 17.9 million square feet of space to the existing 4.5 million square feet, is completed, allowing the re-paid funds to revolve and support other such investments. The plan was included in the Reinvent Phoenix Plan by the Phoenix City Council. A presentation on the evolution of the plan can be downloaded at **http://summit2016.ecodistricts.org/wp-content/uploads/2017/03/1-Beyond-TIF.pdf**.

Traditional measures of financial return often leave out valuable benefits, such the regional economic development impact of an area becoming known for sustainability and innovation. While short-term job creation from construction is well-documented, longer-term benefits, such as improvements in tax yield intensity, long-term job creation, cost-of-living and cost-of-business effects, and supply chain support are left off the table.

If we design for and measure the outcomes we want, we are more likely to succeed in creating those. Quantifying benefits also helps financing entities better recognize their value. Research in recent years makes it easier to document the health, land use, jobs access, transportation, and community benefits of clean, local jobs. Moreover, scoring performance can allow EcoDistrict entities learn what is working and adjust management practices over time.

CONCLUSION

While all of the strategies and technologies we have looked at are being tried in one form or another, for the most part they have yet to be brought to scale. As we seek to accommodate the growth of new manufacturing jobs in the U.S. we have choices to make about how we do that. In many places we are beginning to reimagine what infrastructure means—rather than power plants connected by long transmission and distribution systems to a factory, a district energy system can provide power and heat right in the factory's neighborhood and keep the lights on during storms that would have caused costly interruptions in the past. Industrial EcoDistricts present a way to create jobs while saving energy and water, addressing climate change, and creating an economic benefit for businesses and communities.

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