CHAPTER 1

Europe's Greenest Places

Cities are key to our planet's future. Over half of us now live in cities and an estimated 70 percent of the world's total population will be urban by 2050 -- over six billion people. Will tomorrow's cities continue to waste land, squander resources and contaminate water and air in an escalation of our centuries-old war on the Earth? Or will we build and rebuild cities that return us to a balance with nature in ways that are mutually beneficial to people and our fellow creatures?

Europe's greenest places offer hope for a positive outcome. The 19 cities profiled in this book are reintroducing greenways and stream corridors into the urban landscape, often in ways that assist with floodwater management and biodiversity while reconnecting people with their environment. These cities are building compact, diverse neighborhoods that can easily be navigated on foot or by bicycle and public transportation. They are turning brownfields into ecodistricts that expand the limits of closed-loop energy, waste and water systems. They are cutting the greenhouse gas emissions that cause climate change and pursuing a carbon-free future by fueling district heating and power systems using wind, water, geothermal, biomass and other innovative technologies. Recognizing that individual behavior is crucial to sustainability, these cities motivate their citizens to understand the connection between their lifestyles and the health of the planet. Ironically, while naysayers claim that sustainability is unattainable or unaffordable, these cities are finding that green is good for economic development, generating businesses and jobs in rapidly-growing sectors and attracting the highly-prized creative class with their mix of vibrant urbanity and accessible nature.

What are Ecocities?

Ecocities are communities in balance with nature. But how can we

measure a city's balance with nature? Dozens of ecocity evaluation approaches have been proposed (Joss, 2012). But no single method has yet been chosen due to the vast differences in cities and the time needed to evaluate each approach (Joss, 2015). This book largely uses the evaluation criteria developed by the European Commission for the European Green Capitals award competition and the European Greenleaf contest available to smaller cities. Cities in these competitions are judged by their accomplishments in twelve environmental indicators: climate action, transportation, greenspace/ land use, biodiversity, air quality, noise, eco-innovation, energy performance, integrated environmental planning and management of water, waste and wastewater. The European Green Capitals program also recognizes strategies that motivate citizens to lead more sustainable lives since physical improvements are futile unless accompanied by changes in human behavior.

The European Green Capitals evaluation process is arguably the best currently- available framework for exploring Europe's green places. But, it does not fully address all aspects of a city's balance with nature. For example, the European Commission does not ask applicant cities to estimate their total ecological footprint. A true ecocity would ideally be a one-planet city: it would maintain a level of consumption that Earth could support even if every city in the world consumed resources at that level. In reality, experts believe that three planets would be needed if everyone on Earth had ecological footprints comparable to typical European cities including cities in Sweden, Norway, Spain, Germany and the United Kingdom (Moore, 2015). While the 19 cities profiled in this book are making

Figure 1-1: *Heidelberg is surrounded by the 3,500 square kilometer UNESCO Geo-Naturepark Bergstrasse-Odenwald.*

commendable progress considering their affluence, the European GreenCapitals competition does not ask if their total consumption levels are getting closer to those of the one-planet-city-levels met and even exceeded by many poverty-stricken cities typically found in Asia, Africa and Latin America (Moore and Rees, 2013).

That said, success in the European Green Capitals or European Greenleaf competitions shows that a city is making remarkable progress toward sustainability even though that city may not yet be in complete balance with nature. Consequently, the 19 cities profiled in this book are clearly role models when judged according to the criteria established by the European Commission. In fact, 15 of these cities have either won this award or been named as finalists in the European Green Capital and European Greenleaf award programs.

The twelve environmental indicators in the European Green Capitals program create a comprehensive evaluation process and all twelve are discussed in the city profiles found in later chapters. But to emphasize important distinctions and avoid repetition, this chapter introduces key concepts and examples from the case studies using nine categories: greenspace and green networks; compact, mixed use neighborhoods; pedestrian friendliness; bicycle infrastructure and public transportation; nature and biodiversity; redevelopment of brownfields into ecodistricts; climate action and alternative energy; public engagement; and economic development through sustainability.

Green Structure

Sustainable cities centralize growth while maintaining and often increasing parkland, habitat and other greenspace. Furthermore, these cities put people and nature close together. In most of the cities profiled in this book, the vast majority of residents live within 300 meters of green space. In some, like Vitoria-Gasteiz, Spain, Ljubljana, Slovenia, and Essen, Germany, almost everyone lives within 300 meters of some kind of green area.

However, sustainable cities are not content to simply locate large amounts of greenspace close to people. These cities also strive to connect greenspace in ways that create a synergy for people, wildlife and community resilience. Green structures, (also referred to as green networks, green systems and green frameworks by the cities profiled

in this book), often feature green corridors, or green fingers, that extend radially from the city center to preserved rural greenbelts surrounding compact urbanized areas. These green corridors are sometimes linked by concentric green rings that allow hikers, bicyclists and wildlife to move between greenways with minimal contact with cars and other manmade hazards. Some of green network plans envision a city in which people can use greenways to access schools, community centers, shopping and other daily needs under their own power, creating health benefits as well as recreation and environment-friendly transportation. By locating greenways within floodplains and other logical places, these cities create a green infrastructure that can protect water sources, defend against flash flooding and allow the reintroduction of plant and animal species that previous generations banished. As detailed below, the green structure concept particularly informs the planning and growth of Hamburg, Munster, Ljubljana, Copenhagen, Oslo, Helsinki, Stockholm, Nantes, Freiburg, Vitoria-Gasteiz and Essen.

The best time to plan a green structure was a century ago. And that is exactly what happened in some of these cities. Over 100 years ago, the Chief Building Officer of Hamburg, Germany proposed a web-like Grunesnetz featuring greenways radiating from the city center to the farms and woods of a rural greenbelt. In this plan, the spokes were connected by inner and outer green rings allowing non-motorized transportation throughout the city as well as recreational routes between the parks and, furthermore, between these parks and the surrounding countryside. The inner green ring was formed when the historic city walls were replaced by a string of parks and the Planten un Blomen botanical garden. From this inner ring, hikers and bicyclists can now follow the car-free Alsterwanderweg trail along the Alster River from downtown Hamburg to nature preserves in the city's hinterlands. Although incomplete, Hamburg is committed to protecting the Green Network as it currently exists and closing its remaining gaps (Hamburg, undated; European Commission, 2011).

Figure 1-2: *Hikers, bicyclists and even paddlers can meander the Alster River greenway from downtown Hamburg to the surrounding greenbelt.*

Munster, Germany transformed its former city walls into a walking and bicycling promenade that completely encircles the historic downtown. This green ring and two others connect seven green wedges extending into the Munsterland park landscape, a 6,000-square kilometer district protecting cultural landmarks as well as working farmland and wildlife habitat. One green wedge flanks a modest stream meandering across the city center and grows into a large linear park with a lake, museums and the city zoo (Munster, 2009; Munster, 2016).

Ljubljana, Slovenia created its inner green ring by transforming the strip of land that surrounded the city during World War II when a barbed wire fence separated the urban area from the surrounding countryside. Following liberation in 1945, the city converted this no-mans-land into the Path of Remembrance and Comradeship, a 33-kilometer walking-bicycling trail lined with 7,400 trees. Today, the Path is the site of a memorial walk held every year on the anniversary of the liberation. But year-round, Ljubljana residents use this path to exercise in natural surroundings and to reach many of the city's most popular parks and other destinations without a car (Valentine, 2010).

A 1928 vision for the Copenhagen region concentrated development within the central city and along radial urban corridors resembling fingers separated by rural land called green wedges. Although generally accepted, this concept had little official authority throughout the 20th century. Planners realized that the wedges were particularly vulnerable to sprawl unless they could be transformed into places that the general public would come to love and defend. Over the following nine decades, Copenhagen and surrounding municipalities created parks, forests, athletic fields, community gardens, golf courses and landscape protection areas. Through these efforts, average citizens likely realized the value of these areas and the green wedges were formally adopted by the Denmark Planning Act of 2007 (Copenhagen, 2011; Veire, Petersen and Henchel, undated).

The first parks plan of Oslo, Norway, adopted in 1917, envisioned green fingers along several streams linking the Oslo fiord with the Marka, the forested greenbelt that occupies two-thirds of the city's total land area. Subsequent plans built on that concept: higher density development within centers connected by trails linking schools, sporting fields, community facilities and open space including the surrounding Marka. Economic downturns and war slowed implementation. But Oslo has succeeded in creating a world-class

green finger in Akerselva Environmental Park, which restores much of the Akerselva River to a near-natural state while converting many of the monumental factory buildings from Oslo's water-powered industrial era into restaurants, studios, entertainment venues, offices and housing. Energetic hikers and cyclists can use the trail system along the Akerselva to reach the Marka. But Oslo also offers a subway line from downtown that carries nature-seekers directly to trailheads in the greenbelt (Jorgensen and Kine, 2012).

In 1914, Helsinki, Finland, adopted a green structure plan linking local parks and public facilities with green fingers radiating from the downtown waterfront to farms and forests surrounding the city. Helsinki's 2050 City Plan repeats these goals, noting that increased density heightens the need for a green network that seamlessly connects parks, nature preserves, recreational centers, schools, shopping districts and workplaces. As a textbook example of a green finger, Central Park joins four nature protection areas north of the city with downtown Helsinki, where Cultural Park is home to several public facilities including the Opera House, the botanical garden and the Helsinki Music Center. Apparently pleased with the green structure concept, in 2002 the City Planning Department announced the creation of a highly-ambitious green finger called Helsinki Park incorporating rivers, coves, bays and islands in the Baltic Sea, including the historic Suomenlinna Island Fortress, a UNESCO World Heritage Site (Helsinki, 2013; Helsinki, 2015a; Helsinki, 2015b; Jaakkola, 2012).

Stockholm, Sweden essentially realized that it had created a green structure by concentrating development near its metro system and leaving the areas in between alone. In the 1990s, the Stockholm Regional Planning Office emphasized that these remnant green wedges were important to biodiversity as well as outdoor recreation and other environmental benefits. Today, the green wedges are designated in the regional plan as well as the plans of the region's 26 separate jurisdictions. From 20 to 30 percent of these green wedges are protected in eight nature reserves and the 2010 regional plan calls for additional preservation in its "never far from nature" vision. Many of these green wedges extend into the city center, including National City Park, said to be the world's first national urban park and home to four royal palaces as well as rare plant and animal species (Akerlund, 2011; European Commission, 2010; Floater, Rode and Zenghelis, 2013; Lantz, 2001; Lekberg, 2010; Nelson, undated;

Office of Regional Planning, 2010).

Figure 1-3: *Vitoria's agricultural belt occupies 58 percent of the city's total land area.*

Nantes, France uses its network of over 250 kilometers of rivers

and streams plus 9,500 hectares of wetlands to form its "green and blue framework". The banks of two of these rivers, the Loire and the Sevre, are Natura 2000 sites, a designation applied to almost 13 percent of the city's total land area. Nantes and the 23 surrounding communities are working together to restore aquatic ecosystems and revitalize habitat. In addition, Nantes offers 210 kilometers of "waterside walks" that provide "multimodal green transport" while connecting people with nature (European Commission, 2016; Nantes, 2010; O'Neill & Rudden, 2010).

In 1997, Freiburg, Germany secured the western portion of its greenbelt by protecting 44 square miles of its lowland forest, or Mooswald, in a landscape conservation area that now provides a home for rare species of beetles, bats and woodpeckers as well as recreation for birders and nature lovers. The rest of the greenbelt is formed by the Black Forest, Schauinsland Mountain, the Rieselfeld nature reserve and the vineyards of Tuniberg as well as smaller greenspaces like Seepark, created for a 1986 garden expo, and Mundenhof, Freiburg's wildlife and nature park. Freiburg citizens and tourists can easily escape to nature by crossing a pedestrian bridge from downtown and wandering the trail system in a forested ridge linking to the greenbelt and Freiburg's surrounding countryside (Freiburg, 2008; Freiburg, 2011).

Vitoria-Gasteiz, Spain created its greenbelt by restoring former gravel pits, garbage dumps, a polluted river and a degraded wetland into five major parks that largely encircle the urban center. A network of bike paths extends through this greenbelt, providing planet-friendly transportation options as well as 91 kilometers for exercising close to nature. Vitoria's local planning think tank, the Environmental Studies Centre, refers to the greenbelt as an "eco-recreational corridor" within a green structure consisting of several concentric circles. Outside the greenbelt lies an agricultural belt covering 58 percent of the city's total land area. Beyond the agricultural belt is a green ring of forested mountains which have retained almost all of their native species due to protection from public ownership and ancient rules governing the use of water, pasturage and other resources. In turn, the forest ring links with natural spaces known as the Highland Belt and the pan-European ecological corridor that runs from the Galician mountains to the Alps (Environmental Studies Center, 2012; European Union, 2012; O'Neill & Rudden, 2010; Vitoria-Gasteiz, 2010; Vitoria Gasteiz, 2016).

In 1927, Essen, Germany adopted a green area system plan depicting inner and outer greenbelts connected by roughly 17 green corridors plus a dozen green fingers extending toward the city center. The southern greenbelt along the Ruhr River survived the 20th century largely as shown in the 1927 plan. Essen began implementing some of the plan's other components under a 1975 program that has created over 100 green areas on lands degraded and abandoned by coal mines and steelworks. Today, green areas and open space account for over half of the City's land area and Essen has recommitted to the goal of connecting its greenspace using a strategy called "Essen – New Ways to the Water", which places a 150-kilometer "Green main route network" within 500 meters of more than 250,000 residents. Three north-south corridors within this network link southern green areas along the Ruhr River with restoration projects north of the City including the Zollverine Coal Mine UNESCO World Heritage Site and Emscher Landscape Park, a regional project currently restoring what was once one of the most polluted rivers in Europe. As of 2014, over 500 projects had been implemented under New Ways to the Water (Essen, 2014; EGC, 2015).

Access by Proximity

Compact, multiple-use development reduces transportation problems simply by putting everything people need closer together, if not in the same place. Higher-density, diverse cities, when properly designed, make it easier for residents to get to work, schools, shopping and even greenspace without the need to use or perhaps even own a car. Richard Register, a pioneer in the ecocity movement and founder of Ecocity Builders, used the term "access by proximity" in his groundbreaking 1987 book *Ecocity Berkeley*: "Instead of thinking in terms of *going* places, think in terms of *being* places" (Register, 1987, p. 33). To this day, Register continues to emphasize this often-forgotten point: "It's said 'the fastest route from point A to point B is a straight line.' Not so. It is moving the points closer together" (Register, 2016).

All of the cities profiled in this book stress the significance of multiple-use density in their plans. In 1998, Munich, Germany adopted a new general plan built on three words: compact – urban -

green. Recognizing that access by proximity is essential to all things sustainable, three cities in Germany, Heidelberg, Essen and Munster, all refer to themselves as "cities of short distances." The goal of compact cities is perhaps best illustrated in the following examples from Stockholm, Vitoria-Gasteiz, Bristol, Freiburg and Oslo.

In Stockholm, Sweden, the 1999 City Plan proclaimed that the urban form of this city was largely complete and declared that future growth would be accommodated by infill and brownfield redevelopment. This anti-sprawl goal has been memorialized in the phrase "build the city inwards." The city has achieved international recognition by transforming a formerly-polluted industrial area into a sustainability showcase. This eco-district, called Hammarby Sjostad, is so successful that it has become a tourist destination and an international calling card for Stockholm's green industries. As proof that the city is indeed growing inward, a 2013 study by the London School of Economics found that Stockholm surpassed the urban containment index of twelve comparably-sized cities (Floater, Rode and Zenghelis, 2013).

In Vitoria-Gasteiz, Spain, 81 percent of residents live within 1,500 meters of the city center even though population has tripled since the 1960s. The urban area represents less than 15 percent of the city's total land area but accommodates 98 percent of the population. Vitoria aims to retain its compact form by redeveloping underutilized properties at densities of up to 400 dwelling units per hectare and through a policy known as re-densification. These tactics are working. Between 2001 and 2010, 97 percent of growth occurred within the greenbelt (European Commission, 2010; European Union, 2012; Vitoria-Gasteiz, 2010).

In Bristol, United Kingdom, a 2007 policy channels all development away from greenfield locations and toward brownfield sites. Redevelopment projects here are largely succeeding in

Figure 1-4: The waterside walkways and public spaces of Harborside have revitalized downtown Bristol.

revitalizing a city center that was once highly-dependent on harbor-related industries that have mostly departed to larger ports. In the city center alone, 26 hectares of contaminated land were transformed into Harborside, a high-density, mixed use neighborhood with

waterfront walkways, cycle paths and public spaces that are drawing people back to downtown living. As an indicator of success, 98 percent of business development and 94 percent of residential development occurred on brownfield sites between 2002 and 2012, a period in which population grew by ten percent (Bristol, 2012).

Freiburg, Germany curbs sprawl using "inner development", the redirection of growth to infill sites, particularly underutilized industrial areas and former military bases. In 2006, Freiburg adopted a land use plan that actually reduced the land designated for development. Using compact development, Freiburg estimates that up to 95 percent of growth to the year 2030 can be accommodated within the current city borders (Freiburg, 2008; Freiburg, 2011).

Oslo, Norway directs development to a waterfront district known as Fiord City where three eco-neighborhoods in various stages of revitalization are connected by a pedestrian/bicycle path called the Harbor Promenade. Oslo has the highest growth rate of all European capitals. Nevertheless, it succeeded in locating 80 percent of all growth occurring between 2002 and 2006 on brownfields and other previously-developed land (Oslo, 2009).

Feet First

When cities build compact, multiple-use centers, people have less need for cars and other forms of transportation because they can walk to jobs, shopping, schools and many other everyday destinations. In his inspirational yet practical book, *Walkable City*, Jeff Speck summarizes the importance of walkability this way:

> Walkability is both an end and a means, as well as a measure. While the physical and social rewards of walking are many, walkability is perhaps most useful as it contributes to urban vitality and most meaningful as an indicator of that vitality. After several decades spend redesigning pieces of cities, trying to make them more livable and more successful, I have watched my focus narrow to this topic as the one issue that seems to both influence and embody most of the others. Get walkability right and so much of the rest will follow (Speck, 2012, page 4).

Walkability is easy to visualize but can be hard to accomplish. It requires the political will to prioritize people within the public right of way, ideally by completely pedestrianizing streets and sometimes entire neighborhoods. To repopulate streets with pedestrians, cities are also paying more attention to the quality of the streetscape in terms of scale, architectural diversity and landscape/hardscape design. Interesting examples of pedestrian friendliness can be found in Vitoria-Gasteiz, Barcelona, Copenhagen, Ljubljana, Freiburg, Salzburg, Heidelberg and Munich.

In Vitoria-Gasteiz, Spain, pedestrians get top priority. As mentioned above, a sprawl-curbing greenbelt and higher-density mixed use development have succeeded in putting 81 percent of the city's 242,000 people within 1,500 meters of the city center. In addition, the foundation of Vitoria's transportation strategy is super-blocks. These are actually mini-neighborhoods where the interior streets, called pedestrian-priority streets, are restricted to walkers, bicyclists, deliveries and motorists who live within the super-block. The maximum speed limit on a pedestrian-priority street is 10 kilometers per hour. This reconfiguration of the right of way converts 70 percent of the space previously reserved for cars into car-free public space. All other traffic is limited to the perimeter of the super-block on roadways called private vehicle primary streets. Eventually, Vitoria plans for over half of the roadway system to be pedestrian-priority streets. By combining compact development with pedestrian-friendly infrastructure, Vitoria has already built a city in which over half of all trips occur on foot (European Commission, 2010; European Union, 2012; Vitoria-Gasteiz, 2010).

People love to walk, particularly when the path is interesting as well as safe and when the walkway connects attractive destinations. Barcelona's mile-long La Rambla is a classic example. This pedestrian street links Catalonia Square, a major transportation hub, with the city waterfront using a tree-shaded promenade lined with outdoor cafes, book vendors and craft stalls. Motor vehicles travel on single one-way lanes flanking La Rambla but do not cross the pedestrian space. Prior to hosting the 1992 Olympics, Barcelona joined La Rambla to La Rambla del Mar, a pedestrian bridge spanning part of the harbor and connecting with a former dock now retrofitted with public squares, entertainment venues and the city aquarium. From there, people can

stroll around the marina and meander two more miles of restaurant-dotted boardwalk built on beachfronts that Barcelona created from a previously-derelict port district. The price tag for this pedestrian infrastructure and other improvements was hefty. But Barcelona is now the 5th most popular tourist destination in Europe (Iwamiya and Yeh, 2011; Taylor, 2012).

Figure 1-5: *La Rambla multitasks as a transportation, culture, entertainment and tourism magnet.*

Copenhagen, Denmark was a pioneer in the pedestrian streets movement. In 1962, the city banished non-essential motor vehicles from a one-kilometer segment of Stroget Street. Skeptics predicted disaster. But the car-free atmosphere attracted more walkers, creating what is now a thriving retail/entertainment district. In addition to restricting motorized traffic, Copenhagen pays close attention to the quality of streetscapes. Beginning with its first "public space – public life" study in 1968, Copenhagen has documented the benefits of designing streets with human scale, engaging facades, soft edges and other features that are now part of the official planning tool box. These techniques have been successfully transplanted to New York

City, Melbourne and other cities around the world (Gehl, 2010).

Ljubljana, Slovenia designated its city center as an ecological zone in 2007, closing streets to motor vehicles with the exception of early-morning deliveries. By 2013, the City had expanded the pedestrian district to more than 30 streets, a 550-percent increase. These prohibitions created a quieter and more peaceful downtown, causing measurable decreases in noise levels as well as the more obvious benefits of greater safety, improved air quality and reduction of greenhouse gas emissions (O'Neill and MacHugh, 2013).

In 1973, Freiburg limited access on many streets in its city center to deliveries and the few cars owned by downtown residents. As a result, this historic district serves workers, shoppers, occupants and tourists alike, crowded with people rather than automobiles. At the other end of a tram ride lies Vauban, Germany's largest car-free development, where internal parking is prohibited and only eight percent of residents own cars. As further evidence of pedestrian prioritization, over 90 percent of Freiburg's citizens live in neighborhoods where vehicular speed in limited to 30 kilometers per hour, or less than 19 miles per hour (Berrini and Bono, 2010; Freiburg, 2011; Medearis and Daseking, 2012).

In the center of Salzburg, Austria, people still get around on foot, much as they did in Mozart's day. The Gothic buildings and other architectural gems of the Altstadt form the heart of a 236-hectare UNESCO World Heritage Site here that incorporates the Mirabell Gardens, the Salzach River and surrounding mountains. UNESCO's recognition is based in part on the integrity of the urban fabric, which is logically enhanced by the fact that Salzburg prohibits non-essential motor vehicles on more than five miles of pavement throughout the World Heritage Site (UNESCO, 2015a; UNESCO, 2015b).

In Heidelberg, Germany, the land use plan calls for continued conversion of streets from single-purpose motorways to "living space". As proof that walkability is desirable as well as possible, most streets in Heidelberg's Old Town are already car-less. Perhaps the best example is Hauptstrasse, a mile-long, pedestrianized "main street" that rivals Barcelona's La Rambla for diversity of uses, architectural interest and human scale. Other examples outside the historic district include the Kirchheim neighborhood where traffic calming measures create a pedestrian network between popular destinations on streets

with maximum speeds of seven kilometers per hour or just over four miles per hour (Beatley, 2000; Heidelberg, 2007; James and Fereday, 1999).

In Munich's historic center, pedestrian streets surround Marienplatz, the public square in front of Munich's neo-Gothic town hall, and extend north to the massive Englisher Garden, which also offers its own 78-kilometer network of foot paths and cycle tracks. Just east of downtown Munich, pedestrians can stroll on over 40 miles of paths and bike-friendly roads along the Isar River that lead to the farms and woods in the surrounding greenbelt.

Eco-mobility

After World War II, most US cities began splitting neighborhoods with freeways and surrendering precious downtown space to parking. But in an ill-conceived attempt to accommodate cars, US cities only encourage more to come. In contrast, the communities profiled in this book recognize that cars are insatiable. In addition to the pedestrian features noted above, these cities invest in public transportation and bicycle infrastructure. They often impose speed limits that not only make walking and cycling safer but also motivate more people to kick their auto-dependency. Perhaps the best examples of building cities for people rather than cars can be found in Copenhagen, Stockholm, Vitoria-Gasteiz, Bristol, Nijmegen, Munster, Barcelona, Nantes, Freiburg, Heidelberg and Munich.

In the 1960s, Copenhagen flirted with car culture and even removed a few bike lanes. But realizing the absurdity of designing cities for cars, this city of 562,000 people changed course in the 1970s and 1980s. It converted car lanes and parking spaces to cycle tracks which now flank every major roadway. Maximum speed limits of 30 kilometers per hour (19 mph) or, in some cases, 15 kilometers per hour (9 mph), are enforced on all other streets and bikes are welcome on public transportation. This infrastructure, with a combined length of 411 kilometers, makes it easy for Copenhageners to safely, quickly and healthily commute "door-to-door" by bike. The city provides additional motivation by timing traffic signals to bicycle speeds, giving bikes a head start at traffic lights and removing snow from cycle tracks before car lanes. As a result, 62 percent of Copenhageners bike to work and Copenhagen is widely

acknowledged as the most bike-friendly city in the world (Copenhagen, 2007; Copenhagen, 2011; Copenhagen, 2013; Copenhagen, 2015; Gehl, 2010; UCI, 2014).

At 760 kilometers, Stockholm has an even longer bike-lane network than Copenhagen. This city of 910,000 people also enforces a 30 kilometer-per-hour speed limit on local streets, which helps explain why Stockholm doubled its bike use between 1990 and 2008. In addition, Stockholm puts public transportation within 300 meters of 90 percent of city residents and covers cab fare if buses or trains are delayed more than 20 minutes. In 2007, Stockholm began imposing a congestion charge on vehicles entering and exiting the downtown, a move that decreased city center traffic by 20 percent and increased public transportation ridership by seven percent. Stockholm estimates that the congestion charge alone has annually reduced CO2 emissions by 10 to 15 percent, resulting in 30,000 fewer tons of CO2 emissions per year (Berrini and Bono, 2010; European Commission, 2010a; Floater, Rode and Zenghelis, 2013; Richelsen and Sohuus, 2010; Stockholm, 2008).

Vitoria-Gasteiz, Spain, achieved a 45 percent increase in public transportation ridership by building tram lines, improving bus service and adopting new parking regulations. In addition, Vitoria offers 97 kilometers of cycle lanes/paths in the urban area plus 91 kilometers of pedestrian/cycle paths in the greenbelt. Due to the compact form of this city of 242,000 people, bicyclists can use this cycling infrastructure to reach any destination within the urban area in 15 minutes or less (European Union, 2012; Vitoria-Gasteiz, 2010).

Between 2009 and 2011, Bristol, United Kingdom invested more than 20 million pounds in bicycling improvements, creating a system with 299 kilometers of cycle lanes. This city of 441,000 people is also in the process of imposing a speed limit of 20 miles per hour in all residential neighborhoods. These moves are credited with increasing cycling by 80 percent between 2004 and 2012. In 1982, Bristol and its partners used an abandoned rail corridor to build the Bristol and Bath Railway Path, now the most popular bike trail in the country. Today, bikes on this rail trail carry more people than the trains that used to travel this right of way (Bristol, 2012; Sustrans, 2016).

Figure 1-6: *The Bristol and Bath Railway Path now transports more people than the trains that used to travel this right of way.*

In the Netherlands city of Nijmegen, bike lanes are physically separated from "access" streets and all other roadways, known as "traffic limited" streets, are subject to speed limits of 30 kilometers per hour (19 mph). This city of 171,000 people also provides parking for 5,200 bikes in the downtown and 8,700 bikes at the railroad station as well as 43 kilometers of bicycle superhighways. These are high-speed cycle paths that prioritize cyclists headed for nearby cities as well as universities and other major destinations within town. The people of Nijmegan have responded to the city's investment. Bicycles account for 64 percent of all commuter traffic here and represent 37 percent of all trips of 7.5 kilometers or less, a larger percent than cars (Bicycle Dutch, 2015; Bicycle Dutch, 2016a; Bicycle Dutch, 2016b; European Commission, 2016a; Nijmegen, 2015).

Munster, Germany also imposes a 30 kilometer per hour speed limit on all residential streets and offers a 450-kilometer bike path network in addition to 255 kilometers of cycle paths off of main roads. This city of 300,000 people built Germany's largest bike garage, which provides bicycle repair, sales and lockers as well as storage for 3,300 bicycles. This bike garage, the Radstation, is located

next to Munster's train station and less than 1,000 feet from the Promenade, the 4.5-kilometer cycling-pedestrian path encircling the downtown on the site of the ancient town walls. The Promenade allows car-free access to bike routes that radiate from the city center in all directions. As in Nijmegen, more people commute by bicycle in Munster than by motor vehicles (Munster, 2009; Munster, 2016).

Barcelona, Spain, aggressively promotes bicycling as well as walking. Roughly 72 percent of residents live within 300 meters of Barcelona's bike network. In 2012, the Barcelona bike share system offered 6,000 bicycles at 420 stations and experienced 40,000 trips per day. Barcelona's eco-mobility investments continue to generate enviable mode split statistics showing 80 percent of all trips in this city are accomplished on foot, by bike or on public transportation (Barcelona, 2013; Barcelona Yellow, 2016).

In 1985, Nantes became the first French city to successfully launch modern tram service. By 2014, that tram line was carrying 120,000 passengers daily, making it the third busiest line in the country. Nantes now has three additional tram lines, commuter rail, water buses and a busway. As of 2009, 95 percent of Nantes' 285,000 people lived within 300 meters of high-frequency public transportation. In addition to 210 kilometers of waterside walks, Nantes built 470 kilometers of cycle paths or tracks and serves as a hub for long distance cycle routes including the 365-kilometer trail that follows the repurposed tow path of the Nantes-Brest Canal as well as the 3,653-kilometer EuroVelo Route connecting Nantes with Romania via nine separate countries (European Commission, 2010b; European Commission, 2016b; Nantes, 2010; Nantes, 2014).

Freiburg, Germany began reducing speed limits on non-arterial streets in the 1990s. Today, 90 percent of Freiburg's 220,000 residents live in neighborhoods with 30 kilometer per hour limits, a policy that has reduced noise while improving safety for pedestrians and bicyclists. Freiburg's 420-kilometer bike network incorporates 170 kilometers of bike paths, 120 kilometers of forest/service roads and 130 kilometers of bike-friendly streets. As a result, 30 percent of all Freiburg trips are done by bicycle and another 15 percent occur on foot (Freiburg, 2011; Medearis and Daseking, 2012).

In Heidelberg, Germany, traffic-calming strategies are credited with reducing accidents by 31 percent and casualties by 44 percent (Beatley, 2000). This city of 150,000 people limits traffic to seven

kilometers per hour on some roads, a restriction that encourages pedestrian and bicycle use as well as reducing noise (James and Fereday, 1999). Likewise, Hamburg, Germany motivates cycling by enforcing a 30 kilometer per hour speed limit on almost half of its street system as well as offering 1,700 kilometers of cycle lanes and a bike share system logging more than two million trips per year (Hamburg, 2008; Union Cycliste Internationale, 2014). To reach its stated goal of becoming the cycling capital of Europe, Munich, Germany has established two bike sharing services and a 1,200-kilometer network of bicycle paths and lanes (Munich, 2010; Munich, 2016).

Biodiversity

The cities profiled in this book are largely growing up on previously-developed and often degraded land. Consequently, achieving biodiversity typically requires more than simply protecting existing natural areas. Many of these cities are restoring long-lost habitat by remediating brownfields and renaturing streams that prior generations channelized in a misguided attempt to control flood waters. As discussed above, most of these cities are implementing green structure plans that connect open space using greenways that provide wildlife corridors in addition to various other benefits like water management, ecomobility and car-free recreation for nature-loving humans. Noteworthy biodiversity efforts can be found in Essen, Vitoria-Gasteiz, Mollet del Valles, Nijmegen, Freiburg, Hamburg, Munich, Stockholm, Ljubljana, Salzburg and Heidelberg.

Essen, Germany has a long history with biodiversity. In addition to the comprehensive 1927 green area plan discussed above, Essen established its first nature reserve in 1939. In 2010, Essen signed the Biodiversity in Municipalities Declaration and today conservation protections apply to over 34 percent of the city, including 12 nature reserves and 49 protected landscapes. However, Essen also lies at the heart of the Ruhr Valley, at one time the largest concentration of coal and steel industries in the world. Since 1975, Essen has restored over 100 sites degraded by these industries and completed over 500 projects under its ambitious New Ways to the Water greenspace strategy. Perhaps the biggest challenge is the Emscher River, at one time used as a wastewater canal and considered the most polluted

river in Germany. Together with five other municipalities, Essen is tackling Europe's most comprehensive river naturalization project, called Emscher Landscape Park. By 2020, this consortium will complete the restoration of what were once open sewers into near-natural meandering streams, helping to protect the 109 animal species and 1,500 plant species that live here, including 50 listed species. In addition to promoting biodiversity, Emscher Landscape Park will manage storm water naturally and create a trail system offering recreation, exercise and alternative transportation options for pedestrians and bicyclists (EGC, 2015; Essen, 2014; Treanor, Connolly and McEvoy, 2014).

In the process of assembling its greenbelt, Vitoria-Gasteiz, Spain also created nature preserves out of abused lands, polluted rivers and degraded wetlands. Along the northern segment of the greenbelt, Vitoria rebuilt the Zadorra River to manage storm water and improve stream quality as well as restore wildlife habitat, ultimately becoming a Natura 2000 site. Similarly, the city reengineered the hydrology and vegetation of the previously-disturbed Salburua Wetlands, now home to numerous endangered species including the European mink, one of the most threatened carnivores on the planet. Today, birds literally flock to Salburua, which has been listed as a Natura 2000 site and an internationally-significant Ramsar wetland. In addition, Vitoria's outermost greenbelt, the forests and mountains encircling the city, preserves 91 percent of its native species due to public ownership and traditions that respect the use of natural resources (Environmental Studies Center, 2012; European Union, 2012; O'Neill & Rudden, 2010; Vitoria-Gasteiz, 2010; Vitoria-Gasteiz, 2016).

Figure 1-7: Vitoria-Gasteiz restored Salburua, now a Ramsar wetland and home to numerous endangered species.

Mollet del Valles, Spain, ten miles north of Barcelona, preserves a 700-hectare area known as Gallecs that works as a park within an agricultural and ecological landscape. The city and its partners have rebuilt riverbanks and restored wetlands here in order to manage and treat storm water as well as create habitat for birds and other wildlife. A collaborative effort has also replanted previously degraded lands with indigenous vegetation. Emphasis on organic farming has generated a diverse ecosystem ranging from butterflies and other insects to reptiles, amphibians, bats, hedgehogs and over sixty bird species. Although most of Gallecs is actively farmed, forested or leased for individual garden plots, Mollet del Valles maintains a trail network where hikers and bicyclists can learn about responsible agriculture and ecology while enjoying healthy outdoor recreation. In a city of 52,000 people, the Gallecs open classroom attracts 700,000 visitors per year, suggesting that Mollet del Valles has developed a winning formula for engaging people in sustainability (Consorci de Gallecs, 2015; European Commission, 2015).

Bristol was an early adopter of wildlife protection in the United Kingdom and in 2008 adopted the Bristol Biodiversity Action Plan

which has been recognized as a model by the national government. This plan aims to put people and nature closer together through the creation of 16 local nature reserves and the restoration of Bristol's waterways. The Bristol Wildlife Network now protects habitat and natural corridors on private as well as public land covering 27 percent of the city's total land area. The network includes portions of a bypass of the Avon River known as the Floating Harbor where restoration of former docklands and the introduction of buoyant reed beds have made the water safe for human swimmers as well as returning otter populations. Bristol and its partners are also safeguarding the rugged Avon Gorge, home to 27 species listed nationally as rare and threatened. Further upriver, Bristol protects portions of the Severn Estuary, which has been classified as a European Marine Site, Special Protection Area, Ramsar site and a Special Area of Conservation (Bristol, 2012).

Nijmegen, Netherlands, is currently completing a $465-million project to relocate old dikes, dig an additional channel and create an island in a segment of the Waal River that flows through the city. This project, known as Room for the River, primarily aims to protect Nijmegen from the increasingly high floodwaters resulting from climate change. However, Room for the River will also create parkland, civic space and more room for nature by restoring stream ecology and recreating 30 different types of habitat including mudflats, meadows and forests. Together with partners upstream and downstream, Nijmegen plans to repopulate the Waal River and its reengineered floodplain with species that once lived here, including sturgeon, beaver, sea eagles and otter. Room for the River has already won international awards for innovatively combining water management with urban redevelopment and environmental restoration (Climate Wire, 2012; HUD User, 2015; Nijmegen, 2015).

Freiburg, Germany owns almost one third of the land within its borders, including Germany's largest communal forest. Roughly 90 percent of the 5,139-hectare city forest is protected for nature conservation and almost half is designated as Natura 2000. On the southern edge of the city, Freiburg uses environment-friendly management to safeguard habitat for lynx, chamois, three-toed woodpeckers and over 120 endangered plant and animal species on Schauinsland Mountain, one of the highest peaks in the Black Forest. In 1997, Freiburg established a 44-square-kilometer landscape conservation area in a lowland forest called Mooswald, or moss

woods. Today, Mooswald is part of the European Natura 2000 system, offering protection to rare species of beetles, bats and woodpeckers as well as an easy way for birders and others to get in touch with nature (Freiburg, 2011; Medearis and Daseking, 2012).

Hamburg's 31 nature reserves occupy roughly eight percent of the city's total land area, the highest percentage in Germany. The city's 36 landscape protection areas cover 19 percent of Hamburg, safeguarding ecological as well as cultural and other resources. Hamburg is currently restoring the health of the environmentally-significant Elbe Estuary while simultaneously growing the Port of Hamburg, which is Europe's third-busiest port and the source of over 150,000 jobs. The port and its partners have launched a unique contaminant remediation project and created the 137-square kilometer Hamburg Wadden Sea National Park in the Elbe Estuary, now a UNESCO world heritage site, which preserves the largest mudflat in the world and habitat for over 2,000 animal species (European Commission, 2009; European Commission, 2011; Hamburg, 2008; Hamburg, 2012; Hamburg Port Authority, 2013).

The tree-shaded paths flanking the Isar River create one of Munich's most prominent green corridors. However, the river itself has been dammed, channelized and dehydrated by engineering projects started in the 19th century. By the 1980s, many referred to the Isar as a "dead river". Today, dense development straightjackets much of the river in its current location. But Munich's 1995 Isar Plan aims to resurrect the river by improving its floodwater retention capacity, retooling the riverbanks for recreational greenspace, restoring swimmable water quality and reintroducing the natural floodplain dynamics needed for wildlife habitat. As of 2010, Munich had succeeded in vastly improving eight kilometers of the Isar, creating spawning beds for salmon and other fish as well as beaches, pools and islands that serve as a recreational refuge for the residents of the compact city center (Munich, 2010; Oppermann, 2005).

In many of the cities profiled in this book, biodiversity is a natural outgrowth of park and historic preservation efforts. Stockholm's 1000-plus parks and nature reserves occupy 40 percent of the City and shelter more than 1,500 species (European Commission, 2010.) More than 20 percent of Ljubljana is in some form of nature protection status, with Ljubljansko Barje landscape park alone protecting 135 square kilometers of wetlands, riparian forests and ecologically-cultivated farmlands (EGC, 2014; Ljubljana, 2013). A

UNESCO World Heritage Site protects 236 hectares of Salzburg including Kuputzinerberg Mountain which offers habitat to deer, badgers, martens and chamois, a species of goat-antelope native to the European mountains (UNESCO, 2015). From Heidelberg's old town, hikers can climb the Philosopher's Walk into UNESCO's Geo-Naturepark Bergstrasse-Odenwald, which conserves the biodiversity of 3,500 square kilometers of countryside bounded by the Rhine, Main and Neckar rivers (EGN, 2013; EGN, 2016).

Brownfields to Ecodistricts

The cities profiled in this book convert abandoned or underutilized industrial areas, harbors, rail yards and military bases into models of sustainability. These eco-neighborhoods or ecodistricts often showcase cutting edge planning, architecture and technology while achieving other goals for compactness, ecomobility, climate action and green structure. As sustainability incubators, these cities are attracting green innovators and entrepreneurs that greatly benefit local and regional economies. Some of the best examples can be found in Freiburg, Stockholm, Hamburg, Nantes, Oslo, Heidelberg, Helsinki, Copenhagen, Bristol, Essen, Munich, Salzburg, Munich and Nijmegen.

Freiburg turned a former military base into the Vauban neighborhood, Germany's largest car-free development. Only eight percent of residents here own cars, which they have to park in structures at the perimeter of the complex. Consequently, most residents prefer to commute using public transportation including a tram line directly linking the interior of Vauban with downtown Freiburg. Many dwelling units here use passive solar and a carbon-neutral cogeneration plant supplies heating as well as electrical power to 700 households. Ubiquitous rooftop photovoltaic solar collectors also create enough electricity to power 200 dwelling units. Perhaps most importantly, Vauban is a pleasant place to live, with gardens, landscaped courtyards and people-centric streets where residents can safely walk or bike to schools, shopping, entertainment venues, community centers and nearby tram stops (Berrini and Bono, 2010; Freiburg, 2011; Medearis and Daseking, 2012).

Stockholm, Sweden transformed a highly-contaminated industrial waterfront into Hammarby Sjostad, a model ecodistrict that tests

innovative eco-technology without sacrificing the comfortable feel of a traditional neighborhood. The overriding goal is to cut environmental impacts in half using closed-loop energy, waste and water systems. The 11,000 apartments here are served by a district heating-cooling and electrical generation system that partly uses energy extracted from treated wastewater and solid waste combustion. The advanced wastewater treatment system creates a biogas that powers many Hammarby stoves and ranges as well as buses. Hammarby also makes extensive use of solar panels to heat water and generate electricity. The storm water management system is referred to as "architectonic" because of its aesthetic as well as practical benefits. Storm water is partially retained by green roofs and the residual is channeled into small canals lined with plants that create a landscaping feature while also treating contaminants. Fingers of greenspace reach into every part of Hammarby and link to a nearby nature reserve using a landscaped viaduct called an "ecoduct". Light rail, bus and ferry lines as well as pedestrian trails and cycle tracks make it possible for Hammarby residents to live car-free. In fact, 80 percent of Hammarby residents walk, bike or use public transportation (Floater, Rode and Zenghelis, 2013; Franne, 2007; OECD, 2013; Richelsen and Sohuus, 2010; Stockholm, 2015; URBED/TEN Group, 2011).

Hamburg is containing sprawl by converting obsolete industrial, port, rail, post office and military facilities into sustainable neighborhoods. HafenCity, a former dock and industrial area, is now a 155-hectare ecodistrict planned for 12,000 residents and 45,000 jobs located minutes away from downtown Hamburg via metro rail and served by a district heating system fueled by renewable energy sources. Described as a "City of Plazas, Parks and Promenades", 37 percent of HafenCity is publicly-owned or publically-accessible open space. HafenCity is also the home of Hamburg's newest architectural icon, Elbe Philharmonic Hall, which perches atop an old warehouse and ranks as Hamburg's tallest occupied building (European Commission, 2011; Hamburg, 2008; Kreutz, 2010).

Ecodistrict Ile de Nantes, one of three eco-neighborhoods in Nantes, France, revitalizes an island in the Lorie River that once housed a foundry, ship building yard and other port-related industries. Mixing worksites, retail and civic space as well as residences, this project uses a district heating network fueled by waste and wood, solar thermal installations, photovoltaics and an

aerothermal heat pump. Some of the former industrial structures here have been repurposed as landscape architecture, including the Foundries Garden, which houses 200 trees and 100 plant varieties within the girders and furnaces once used to forge propellers. The former shipyards are now the home of Island Machines, a truly unique enterprise that builds whimsical animated artworks including a mechanical elephant that lumbers around the island carrying more than a dozen passengers on its back (Hure, 2013; Nantes, 2010).

Figure 1-8: *Oslo transformed a former shipyard into the walkable, high-density mixed use neighborhood of Aker Brygge.*

Since the 1980s. Oslo, Norway has been concentrating growth in Fiord City, a string of waterfront sites no longer needed for port-related industries. The first phase, Aker Brygge, turned a former shipyard into a high-density district of residences, offices, restaurants and public spaces designed for maximum walkability. Across a pedestrian bridge, the next phase, Tjuvholmen, features similarly compact mixed-use development anchored by a luxury hotel and an art museum designed by Renzo Piano. Oslo is currently completing phase three, Bjorvika, which positions high rise residential and office towers next to the central train station. On the fiord itself, the city's opera house invites people to climb around the marble-clad roof to

get a 360-degree view of Oslo's spectacular setting between the blue of the water and the green of the forests (Gehl, 2010; Oslo, 2009).

Heidelberg's Bahnstadt converts a former railroad freight yard into an ecodistrict that blends residential units with office space, schools, movie theaters, kindergartens, retail stores and a private university. The futuristic Sky Labs building here welcomes science and technology innovators. Compact, mixed-use design emphasizes eco-mobility and Bahnstadt further pushes the energy-conservation envelope by requiring all buildings to meet extremely low "passive house" efficiency standards. With an area of 116 hectares, Bahnstadt becomes the world's largest passive house district (Heidelberg, 2007; Lisella, 2014; Passive House Institute, 2014).

In Helsinki, Finland, the relocation of port facilities from the city center creates infill sites for sustainable developments close to downtown. A former harbor/warehouse/industrial district became Ruoholahti, now home to 6,000 residents and 12,000 jobs served by buses, trams and metro rail. To enhance Ruoholahti's waterfront image, the city built a canal flanked by greenspace and pedestrian paths that link playgrounds and other amenities here. On the other side of downtown, Helsinki converted a former ceramics manufacturing complex and its environs into the Arabianranta district with the goal of creating the Baltic region's preeminent center for art and design. As of 2009, Arabianranta was home to three art libraries, the largest art university in the Nordic countries, an art museum/gallery, a conservatory and a public art trail funded by a percent-for-art requirement. Arabianranta also showcases earth-friendly design including waterfront raingardens that capture and treat runoff before it reaches the Vantaa River and the nearby Lammasarri Natura 2000 site (Helsinki, 2009; Jaakkola, 2012; Jokinen, 2015).

Copenhagen concentrates earth-friendly growth as close as possible to the city center on remediated industrial, military, port, and rail facilities. From the Orestad neighborhood, a portion of which was previously military property, residents reliably reach downtown in less than ten minutes on high-frequency metro trains. To reduce commuting time even more, Orestad is steadily growing its own job sites including the headquarters of the Danish broadcasting corporation and Copenhagen Concert Hall. Orestad incorporates generous amounts of landscaped open space as well as protected wetlands and a storm water management system called SUDS. The Sustainable Urban Drainage System, or SUDS, locally treats runoff

from roadways before adding it to rooftop discharge and releasing both to the meandering canals that add recreational options for residents and complement Orestad's overall design (Copenhagen, 2011; Copenhagen, 2012; European Commission, 2012).

As detailed in later chapters, all of the other cities in this book have their own brownfield redevelopment stories to tell. Bristol transformed 26 hectares of contaminated land into Harborside, a high density, mixed use project with waterside walkways, cycle paths and lively public spaces including the city's new central plaza, Millennium Square (Bristol, 2012). Essen converted a former railroad freight yard immediately north of downtown into Green Centre of Essen – University District, which combines residential, commercial and office uses close to cultural venues, shopping, the city's central public transportation hub and the Rhine Rail cycle trail (Essen, 2014). Munich retooled its old airport into Messestadt Riem, a new town with subway service and an extensive bike/pedestrian trail network that protects half of its 560-hectare area in open space while using the other half to accommodate an expected 14,000 people and 20,000 jobs (Munich, 2004). Salzburg changed an area that included its former soccer stadium into a mixed use district showcasing the energy savings achievable by retrofitting existing structures, erecting highly-efficient new buildings and employing alternative technologies including a thermal solar energy plant connected to a local district heating system (Bahr, 2014). Munster redeveloped former military grounds into Car-Free Garden City Weissenburg where residents cannot own cars yet can easily get to work and shopping using public transportation, Munster's extensive bicycle network and a car sharing station located at the edge of the project (Baumer, 2009; Munster 2016). In Nijmegen, the Hessenberg project turned a former newspaper/printing complex into a ten-building mini-neighborhood of apartments and retail space within an intricate network of gardens, courtyards and pedestrian alleyways reflecting this district's pre-automobile configuration (Europaconcorsi. 2015; Nijmegen, 2015).

Climate Action and Alternative Energy

Ecocities use a wide range of strategies to minimize the greenhouse gas emissions that cause climate change. They weatherize

existing buildings and erect new structures that employ advanced solar, photovoltaic and district heating/cooling technologies. The cities profiled in this book also generate heat and power using wind, water, geothermal, biogas, biomass and other planet-friendly fuels. Many have pledged to meet ambitious deadlines for becoming carbon neutral and are making huge investments to meet those targets. Some of the most aggressive programs are located in Stockholm, Hamburg, Copenhagen, Freiburg, Nijmegen, Bristol, Essen, Heidelberg, Oslo, Torres Vedras, Munster and Ljubljana.

Between 1990 and 2005, Stockholm cut per capita greenhouse gas emissions by 25 percent largely through the use of renewable energy in its district heating network, which served 80 percent of the city in 2015. District cooling systems alone reduce CO2 emissions by 60,000 tons per year here. Stockholm is also testing closed-loop technologies in its ecodistricts including Hammarby Sjostad, where energy from wastewater and solid waste combustion generates electricity and powers a district heating and cooling district system serving 11,000 households. In addition, Stockholm reduces emissions using compact development served by extensive public transportation and bikeway networks. Based on its progress to date, Stockholm aims to be fossil fuel free by 2040 (Berrini and Bono, 2010; European Commission, 2010; Floater, Rode and Zenghelis, 2013; Frane, 2007; Stockholm, 2008; Stockholm, 2015).

Hamburg reduced per-capita CO2 emissions over 25 percent between 1990 and 2005 by launching renewable energy projects, forming energy-saving partnerships with private industry and expanding its already-green transportation infrastructure, which locates high-frequency public transit within 300 meters of almost all Hamburg households. Leading by example, the city cut energy use in 65,000 units of public housing, fuels power generators and district heating networks with municipal waste and sponsors attention-getting projects like Energy Bunker which converted a World War II flak tower into an alternative energy showcase featuring photovoltaics and a massive reservoir heated by solar thermal, biomass, wood and waste heat from a nearby industrial plant. In 2003, the City and its partners launched the Eco-Partnership Project, a public-private effort that uses various incentives to annually save 163,700 tons of carbon emissions, 26,500 tons of waste and 712,300 cubic meters of water (Berrini and Bono, 2010; Dezeen, 2014; European Commission, 2011; Hamburg, 2008; Hamburg, 2012; Hamburg, 2015; Hamburg,

2016).

Copenhagen aims to be the world's first carbon free capital by 2025. In less than ten years, Copenhagen plans to be a net exporter of power from a biomass and wind-based system. To meet that goal, the city committed to installing 30,000 square meters of photovoltaic panels on municipal buildings and erecting 100 wind turbines with a combined capacity of 360 MW. Experts believe that Copenhagen will hit its 2025 target given the fact that the City cut carbon emissions a remarkable 40 percent between 1995 and 2012. Much of this reduction resulted from switching from coal to biomass in the combined heating and power districts that serve 98 percent of all households in the City. In addition, Copenhagen seems to thrive on its carbon diet: between 2005 and 2014, City population rose by 15 percent and its economy grew by 18 percent while its carbon emissions fell by 31 percent (Copenhagen, 2011; Copenhagen, 2015; European Commission, 2012; European Commission, 2014; O'Neill and Rudden, 2012).

For decades, Freiburg has been at the forefront of energy conservation and alternative energy technologies. This city of 220,000 people created Germany's first passive solar high rise building as part of the energy retrofit of an entire 2,000-household neighborhood. As of 2009, over 1,000 photovoltaic collectors covered the rooftops of Freiburg's public and private buildings. Perhaps the most famous symbols of "Solar City" Freiburg are the photovoltaic array atop the soccer stadium and Heliotrope, the completely solar-powered 1994 house that rotates for maximum sunlight capture. Not content with these accomplishments, Freiburg aims to put solar collectors on every home in the City. In fact, if solar panels are not installed on a new dwelling, the city requires that the roof at least be built to accommodate solar photovoltaic or thermal systems in the future. As of 2009, Freiburg's 140 cogeneration plants produced roughly half of the city's power and district heating needs. The city relies heavily on hydropower as well as solar and biomass, powering its extensive tram network entirely by renewable energy. In a possibly unique application, seven small hydroelectric plants are partly fed by the "Bachle", the tiny water canals that Freiburg restored within the streets of the pedestrian zone of the historic city center (Freiburg, 2011).

Between 2008 and 2014, Nijmegen reduced per capita carbon emissions over 16 percent partly by gaining energy-conservation

commitments from the city's largest companies and institutions including public utilities and the city itself. These commitments alone saved almost 300,000 tons of CO2. Currently, Nijmegen is converting a huge coal fired power plant on the Waal River to an alternative energy showcase featuring solar, wind, biomass and other renewable energy sources. In the longer term, Nijmegen is implementing an ambitious plan to install 16 wind turbines, a million solar panels and 40,000 solar boilers as well as a district heating network for 11,000 households plus increased reliance on biomass and geothermal, all with the goal of being energy-neutral by 2045 (European Commission, 2016; Nijmegen, 2015).

In 2000, Bristol became the United Kingdom pilot for ICLEI's Cities for Climate Protection program. By 2009, the City surpassed the targets established by the European Union and United Kingdom, aiming for a 40 percent carbon-emission reduction by 2020 and an 80 percent reduction by 2050 using a 2005 baseline. Between 2005 and 2010, Bristol lowered its emissions 19 percent, achieving the lowest CO2 emissions per capita of all major cities in the country. Leading by example, Bristol installed the first city-owned wind farm in the United Kingdom and also became the first city in the country to fuel its boilers with wood waste from its own parks and street trees. All new developments here are required to install on-site renewable-energy sources capable of achieving emission-reduction goals that are 20 percent more ambitious than the national code. A complex here called CO2 Zero was the first residential development and the first live-work development in the country to achieve a near-zero standard for heating, light and ventilation (Bristol, 2012; United Kingdom, 2009).

Figure 1-9: Torres Vedras is on its way to generating all of its electricity by wind power.

Essen, Germany targets carbon emission reductions of 40 percent by 2020 and 95 percent by 2050 compared with 1990, which is

substantially more ambitious than the goals established by the European Union, Germany and the State of North Rhine-Westphalia. To reach these targets, Essen formed an independent Climate Agency which helps building owners analyze, plan, finance and complete energy retrofits. Leading by example, the city itself uses 100 percent green electricity in its operations and requires all of its new buildings to meet passive house standards. The 17 buildings in Essen's Gruga Park are served by a local heating district fueled entirely by the park's garden wastes. Essen also uses domestic waste in a waste-to-energy plant that generates electricity as well as enough heat to meet 20 percent of the City's total demand through the city's district heating system (EGC, 2015; Essen, 2014; O'Toole, McEvoy and Campion, 2015).

In 2000, Heidelberg, Germany formed an Energy Efficiency Agency tasked with saving 6 million kWh annually by retrofitting three percent of the region's older buildings every year. In addition to cutting carbon emissions, this program was projected to create 1,100 jobs and inject 110 million euros of direct investment into the local economy. Heidelberg also uses alternative energy in city-owned properties, with the extra revenue to the city's power supplier reinvested in renewable-energy improvements including photovoltaic systems on schools and a biogas heat/power plant at the zoo fueled by animal waste (Herrmann, 2002; ICLEI, 2007).

All of the other cities profiled in this book also pursue strategies to curb greenhouse gas emissions. Oslo generates almost all of its power hydroelectrically and it aims to further cut fossil fuel use by expanding its district heating system using waste-to-energy and bioenergy plants (European Commission, 2009; Oslo 2008). Torres Vedras, Portugal already harnesses coastal breezes in nine wind farms and plans to expand turbine capacity to 332 GWh, which would supply the city's entire electrical energy demand (Torres Vedras, 2014). In 2015, Munster became the first German city to divest its pension fund of oil, gas and all other fossil fuels, explaining that such investments are incompatible with the City's climate protection goals (Mattauch, 2015). Ljubljana, Slovenia targets up to an 80-percent reduction in greenhouse gas emissions between 2008 and 2050 by using a combination of compact growth, energy conservation and a transportation strategy in which public transport and non-motorized travel account for twice as many trips as cars by the year 2020 (EGC, 2014).

Public Engagement

Sustainability cannot be achieved by relying solely on improvements in public transportation, bike networks, alternative energy generation and other eco-infrastructure. Personal behavior is just as important (Moore, 2015). For a new tram line to reduce carbon emissions, for example, people have to ride it. Consequently, the European Green Capitals program asks applicants how they are engaging citizens in planning their communities and motivating them to lead planet-friendly lives. Some cities that are nurturing greener lifestyles include Helsinki, Essen, Nantes, Torres Vedras, Freiburg, Mollet del Valles and Salzburg.

Helsinki's Eco-Viikki, Finland's largest sustainability laboratory, incorporates homes, schools and day care centers within an easy walk or bike ride from shopping, jobs and the science campus of the University of Finland. The buildings here, bristling with solar collectors and photovoltaic panels, are separated by linear open spaces that maximize solar access and passive recreation while managing rainwater retention for use in individual garden plots for nearby residents. However, even the greenest community will not succeed without the cooperation of its inhabitants. As noted by Eco-Viikki's Project Manager: "… sustainability of a residential area depends first of all on the lifestyle of its inhabitants" (Helsinki, 2010; Joss, 2011; Rinne, 2009).

Figure 1-10: *Helsinki's Eco-Viikki neighborhood engages residents in extremely local agriculture as well as recycling, alternative energy, water management and sustainable lifestyles.*

In naming the winner of the 2017 European Green Capital award, the European Commission praised Essen, Germany for accomplishments in climate action, noise abatement, waste reduction, brownfield revitalization and the growth of a greenway network connecting largely-restored open space areas constituting over half the land area of the City. Importantly, the European Commission noted that while the city has led by example, it has also focused on public education and citizen involvement in its sustainability planning and implementation: "The City is making admirable efforts to establish itself as a 'City in transformation' that is overcoming a challenging history to reinvent itself as a 'Green City' and a leading example for others. The City credits its citizens and their ability to change as key to this success and this ethos is visible through their application tag line "ESSENtials – changing the way we act"' (EGC, 2015).

Similarly, Nantes' winning application for the 2013 European Green Capital award stressed that "cities will not achieve their objectives without the citizens." In that year, the city sent its green message into the streets using a fanciful 53-foot high Flying Greenhouse powered by on-board composting. Nantes families compete in neighborhood teams to show how they can pursue international carbon reduction goals using practical, measurable and sociable activities. The Nantes Exhibition Center also hosts learning experiences like "my life – my town – my planet" that help students understand the connection between their actions and the health of Mother Earth (Nantes, 2010; European Commission, 2016).

Torres Vedras uses its Center for Environmental Education to showcase green technology and engage students in sustainable living programs (Torres Vedras, 2014). In Freiburg, 50 schools, churches and other groups have become stream sponsors, which often involves the removal of invasive species and the restoration of native aquatic habitat (Freiburg, 2011). In Mollet del Valles, an estimated 700,000 people per year visit Gallecs and many undoubtedly learn a thing or two about organic agriculture, sustainable forestry and biodiversity while enjoying the miles of trails in this outdoor classroom (Consorci de Gallecs, 2015). In Salzburg, residents were fully involved in planning the transformation of a district of neglected buildings into the revitalized Lehen district featuring energy-efficient residences

served by neighborhood facilities including a public library and elderly daycare center (Bahr, 2014).

Green is Good

Critics sometimes argue that we cannot afford sustainability no matter how appealing and rational it may sound. Many of the cities in this book illustrate that we cannot afford to reject sustainability. Some of these cities are getting more prosperous because their pioneering work is growing exportable green sector goods, technology and expertise that increase job opportunities and expand the local economy. In addition, the greenspace, bike culture and diverse centers of ecocities are likely to attract innovators, entrepreneurs, investors and other members of the creative class essential to a post-industrial economy. Freiburg, Copenhagen, Hamburg, Stockholm, Bristol, Nantes, Ljubljana and Torres Vedras are among the cities proving that healthy economies are possible not just despite sustainability efforts but also because of these initiatives.

Freiburg's economy has benefited handsomely from the city's early commitment to sustainability in general and solar energy in particular. Europe's largest institute for applied solar energy research was launched here in 1981 and today it consults around the world with a staff of 800 employees. In addition, 2,000 solar enterprises now operate in the Freiburg region generating 650 million euros annually and employing 12,000 workers. Each year, an estimated 25,000 academics, students, researchers and other "specialist tourists" come to see Freiburg's success firsthand, increasing eco-tourism income. Green-leaning visitors are often so impressed that they move here, an in-migration that at least boosts support for the city's sustainability goals and in some cases leads to new businesses (Freiburg, 2011; Rohracher and Spath, 2012).

By pushing the green envelope, Copenhagen and Denmark as a whole have added new, growth industries to their economies. In 2010, the Danish wind industry employed 25,000 workers and was growing by 30 percent every year. The green sector as a whole in the Copenhagen Region grew 55 percent between 2005 and 2009 and is now seen as an important wealth generator and economic engine. Public-private partnerships have formed to help firms profit from this momentum, including Green Businesses, a network of almost

1,000 companies working here on noise reduction, air pollution and water contamination as well as fossil fuel consumption (Copenhagen, 2011; Copenhagen, 2015).

Hamburg is expanding its already substantial industrial sector using incentives and regulations to maximize energy efficiency and minimize waste of all kinds. As of 2009, more than 600 renewable energy companies were located in and around Hamburg. The city grows its exportable expertise through the Hamburg Renewable Energy Cluster which facilitates networking between local firms, institutions, universities and NGOs to inspire and support enhanced research and development. By 2011, two global manufacturers of wind turbines located in Hamburg and the Renewable Energy Cluster had grown to 163 companies, putting Hamburg on the map as a world center for alternative energy innovation (European Commission, 2011; Hamburg, 2012).

Stockholm's Hammarby Sjostad ecodistrict develops and tests alternative technologies in search of new ways to cut environmental impacts in half using closed-loop energy, waste and water systems.

Figure 1-11: *The eco-innovations of Hammarby Sjostad create an international calling card for Stockholm's engineers, architects and planners.*

The success of Hammarby and Stockholm's other planet-friendly initiatives has nurtured a workforce with green expertise and skills in advance of growing worldwide demand for sustainable development. Hammarby alone attracts 10,000 visitors every year, an indication of how Stockholm has effectively branded itself as a pioneer in this field. A study by the London School of Economics found Stockholm to be one of the world's leading cities in the development of ecodistricts and green solutions, expertise that can be marketed internationally and used to attract investment, innovators and skilled professionals in a "…virtuous cycle of green growth" (Floater, Rode and Zenghelis, 2013; Franne, 2007).

Like Stockholm, other cities profiled in this book attract new residents and well as international visitors with their focus on sustainability. Due to its highly educated work force, Bristol has landed many leading environmental organizations like City Farms, Forum for the Future, the Schumacher Institute and the national headquarters of the Environment Agency (Sawday, 2012). In 2013 alone, Nantes hosted over 20 international events on sustainability issues including the World Mayor's Summit on Climate Change and the Ecocity World Summit (Nantes, 2014). The greening of Ljubljana helped this Slovenian city double tourist visits between 2002 and 2014 (Ljubljana Tourism, 2016). In addition to promoting its beaches and historic monuments, Torres Vedras uses an energy and tourism tech trail to attract visitors interested in learning about this city's progress in energy conservation and eco-mobility as well as wind power (Portugal, 2015).

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