San Francisco
Sustainable Neighborhood Dashboard

A Capstone Presented to the Faculty of Architecture, Planning
and Preservation
COLUMBIA UNIVERSITY

In Partial Fulfillment
of the Requirements for the Degree
Master of Science in Urban Planning

by

Kate Galbo

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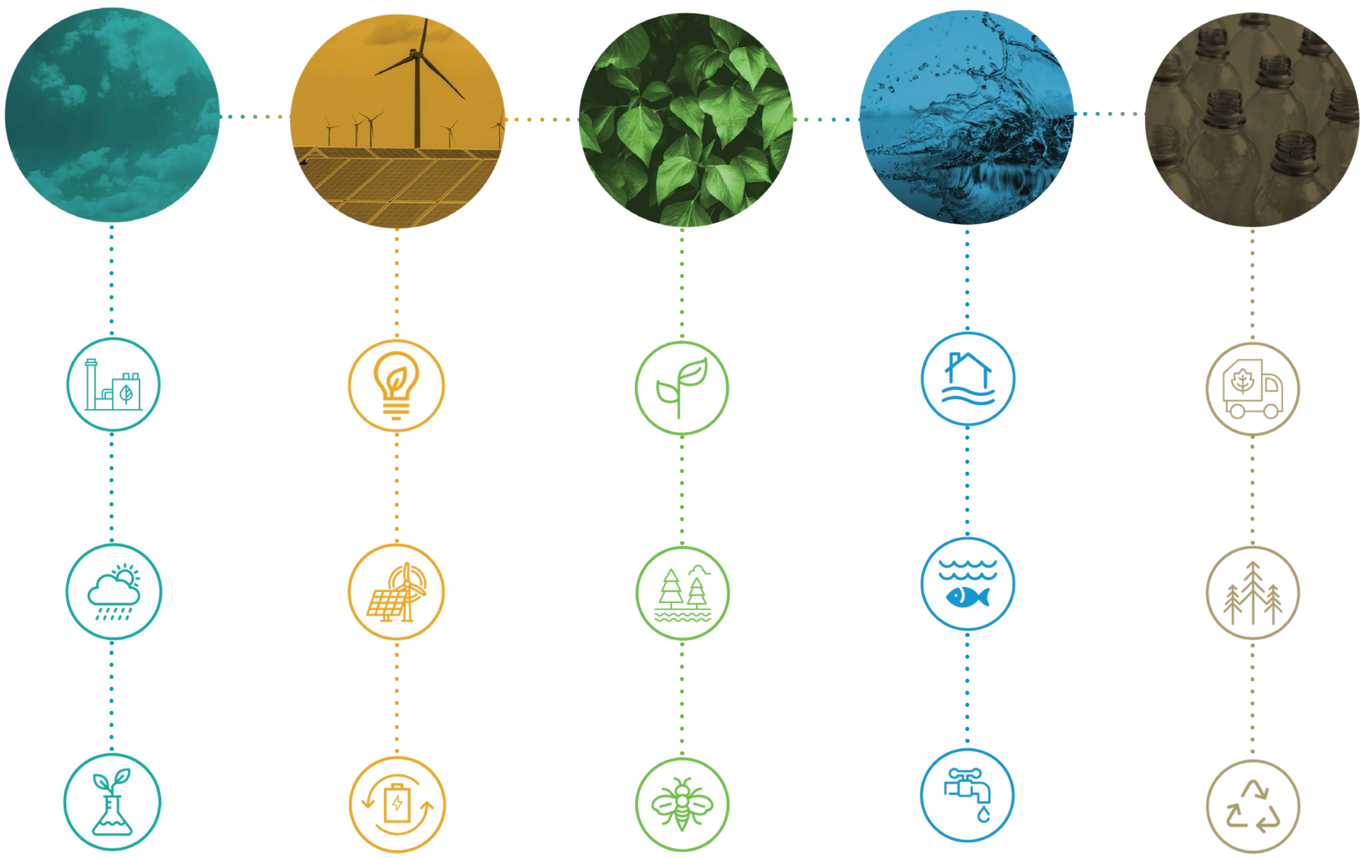
San Francisco Sustainable Neighborhood Dashboard



A Capstone Project for the San Francisco Planning Department
Prepared By: Kate Galbo
May 2020

ABSTRACT

San Francisco's commitment to help reduce global warming by achieving a zero-emission city by 2050 requires multi-scaled action and collaboration between agencies. The City has many plans and policies in place to reduce greenhouse gas emissions across sectors. The San Francisco Planning Department is leading the development of the Sustainable Neighborhood Program, in collaboration with partner agencies, to synthesize the City's many goals, requirements, and targets, create synergies between, often siloed, topics, and maximize mutual efficiencies and outcomes.

The Sustainable Neighborhood Dashboard is a tool created to help demonstrate the potential for data to inform urban sustainability strategy development and prioritization at the community level. The purpose of the Dashboard is to assess and visualize key indicators to provide project sponsors, community stakeholders, and city staff with an understanding of baseline sustainability performance and to facilitate data-driven interventions. The indicators allow users to determine where the largest performance gaps and disparities are and where to focus sustainability-related efforts. This report documents research conducted to create an in-depth assessment of sustainability indicators used in the Dashboard, as well as recommendations for improved data collection and reporting.

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TABLE OF CONTENTS

PROJECT BACKGROUND AND APPROACH

CLIENT INFORMATION

The client for this project is the **San Francisco Planning Department** (San Francisco Planning). San Francisco Planning's Resilience and Sustainability Program aims to amplify performance, health, and quality of life throughout San Francisco's built and natural environment. Through long-range plans and policies, community area plans, major developments, and tools, staff support climate protection, resilience, and equity at the city-wide and neighborhood-scale. Efforts aim to support and exceed existing environmental regulations, maximize co-benefits, and facilitate widespread innovation and implementation.

INTRODUCTION

San Francisco's commitment to help reduce global warming by achieving a zero-emission city by 2050 requires multi-scaled action and collaboration between agencies. The City has many plans and policies in place to reduce greenhouse gas (GHG) emissions across sectors. The 2013 Climate Action Strategy (CAS) set the goal of zero waste, 50 percent sustainable trips, 100 percent renewable energy, and carbon sequestration (0-50-100-Roots).[1] Building on the 2013 CAS and subsequent technical reports, the City is in the process of creating the 2020 CAS update, which aims to achieve zero waste, 80 percent sustainable trips, 100 percent renewable energy, and carbon sequestration by 2030 (0-80-100-Roots) and set the path to net zero emissions by 2050.[2]

The City is also doing work to address resiliency to climate-related hazards. The City has long been seeking to address the risk of earthquakes but began tackling sea level rise in 2013. Thus far, San Francisco has adopted Capital Planning Guidance, issued the Sea Level Rise (SLR) Action Plan, and recently published a SLR Vulnerability and Consequences Assessment.[3, 4, 5] The San Francisco Department of Public Health (DPH) produced the Climate and Health Adaptation Framework in 2017 to reduce climate health risks including extreme heat, sea level rise and inundation, air pollution, illness and disease, and wildfire and drought.[6] Most recently, the City updated its required local hazard mitigation plan to include climate hazards and climate adaptation. This newly titled Hazards and Climate Resilience Plan was approved by the Federal Emergency Management Agency (FEMA) and the California Governor's Office of Emergency Services (CalOES) at the beginning of April and is headed for adoption at the San Francisco Board of Supervisors.[7]

San Francisco is home to some of the world's most innovative environmental regulations. The San Francisco Green Building Code (GBC), which sets high green building standards for all new construction and certain major alterations, was updated this year to include a preference for all-electric buildings.[8] GBC requires all new residential projects achieve LEED Silver and all commercial projects achieve LEED Gold.[8] Since the 2010, GHG Reduction Strategy, San Francisco Planning has introduced additional measures to address GHG emission reduction strategies at the project level. Projects must apply for a determination of consistency with the GHG Reduction Strategy through completion of the GHG Emissions Compliance Checklist.[9] In 2017, San Francisco further demonstrated leadership by becoming the first U.S. city to require solar and living roofs on more new construction.[10]

Although there are many City policies and regulations to respond to the global climate crisis, they are spread across many different documents which may result in missed opportunities for projects to leverage investments to sustainability, resilience, and climate.

SUSTAINABLE NEIGHBORHOOD PROGRAM

San Francisco Planning is often the first to interface with project sponsors and stakeholders, and frequently acts as the convener between agencies, putting the agency in the unique position to support integrated sustainability measures. San Francisco Planning is leading the development of the Sustainable Neighborhood Program (the Program), in collaboration with partner agencies, to synthesize the City's many goals, requirements, and targets, create synergies between, often siloed, topics, and maximize mutual efficiencies and outcomes. The Program was introduced to the San Francisco Planning Commission in January 2020 and was inspired by the opportunities and challenges presented in the San Francisco Planning's participation in the design, review, and approval processes associated with major development projects.[11]

The Program consists of a Vision Framework (the Framework) centered on five (5) goals and fifteen (15) targets/objectives that align with current City initiatives:

1 Healthy Air (zero emissions, non-toxic, comfortable)
2 Renewable Energy (carbon-free, efficient, smart)
3 Robust Ecosystems (green, biodiversity, healthy)
4 Clean Water (high-quality, regeneration, flood-safe)
5 Zero Waste (responsible, reduced, recovered)

The Framework integrates three (3) essential imperatives—equity, resilience, and climate—for thoughtful strategy development and implementation. The Framework was guided by five (5) key principles: (1) people-centered and compelling, (2) built on best practices, (3) effective and efficient, (4) compelling and easy to use, and (5) flexible and scalable. In addition to the Vision Framework, the Program is comprised of three implementation tools: a program summary document, Roadmap (project worksheets), and an online guide (forthcoming).

The Framework is designed to provide a vision for sustainable development and leverage system-based approaches to regulatory compliance, encouraging projects to exceed minimum standards, provide additional co-benefits, and achieve net-positive results.[12] The Framework intends to streamline, without adding to, the inter-agency review process through its consistent platform for integrating environmental sustainability objectives into design and decision making.

PROJECT SCOPE + APPROACH

The **Sustainable Neighborhood Dashboard** (the Dashboard) is a tool to help demonstrate the potential for data to inform urban sustainability strategy development and prioritization at the community level. The purpose of the Dashboard is to assess and visualize key indicators to provide project sponsors, community stakeholders, and city staff with an understanding of baseline sustainability performance and to facilitate data-driven interventions. The indicators allow users to determine where the largest performance gaps and disparities are and where to focus sustainability-related efforts.

The purpose of this project is to develop a dynamic tool for data-driven sustainability assessment through completion of three (3) primary tasks: (1) Initial Assessment, (2) Indicator Assessment, and (3) Data Analysis and Visualization.

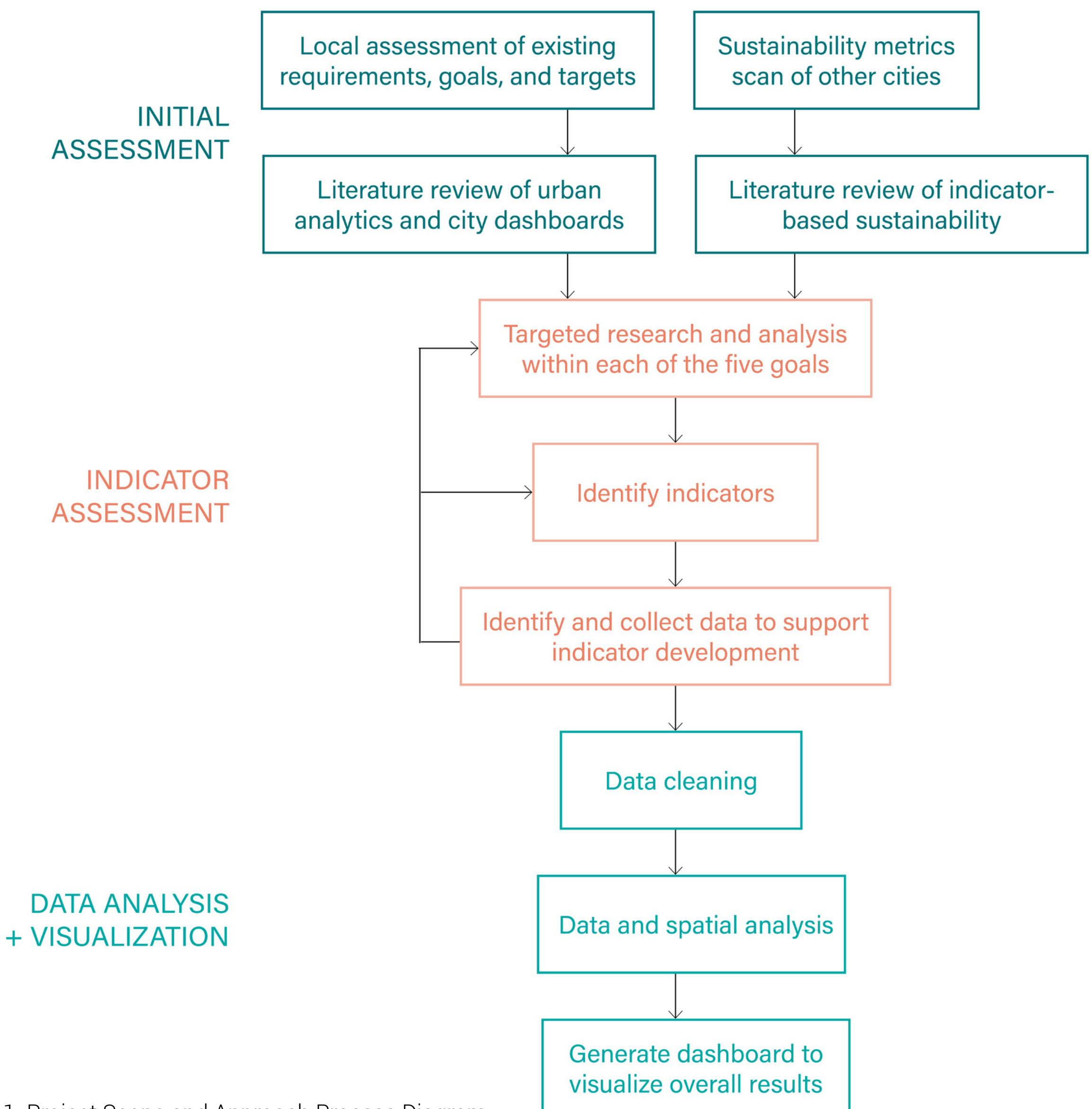

Figure 1. Project Scope and Approach Process Diagram

TASK 1: INITIAL ASSESSMENT

The purpose of the Initial Assessment was to evaluate best practices in urban sustainability assessment and analytics to develop a set of guiding principles to lead the Indicator Assessment and Dashboard creation process. This project incorporates a variety of methods to assess data-driven sustainability performance. Background research was facilitated, first, by reviewing existing frameworks for urban sustainability, which included a thorough analysis of San Francisco policies and regulations to gain an understanding of requirements and targets. Other cities' use of frameworks and indicators were assessed, starting from an initial database compiled by San Francisco Planning, through review of key documents from major U.S. and European cities. Additional background research included analysis of literature focused on existing methodologies and critiques for indicator-based sustainability assessment and urban analytics and dashboards.

Task 1 Deliverables:

- *Part I. Initial Assessment*: a written assessment of urban sustainability indicators and literature focused on sustainability assessment and urban analytics used to develop a set of Guiding Principles
- *Table 1. Review of Existing San Francisco Requirements and Goals*: a table examining San Francisco requirements and goals that align with each of the Framework's 15 targets
- *Appendix A. Sustainability Metrics Matrix*: survey of the use of sustainability indicators and targets in other major cities

TASK 2: INDICATOR ASSESSMENT

Additional research was conducted to finalize a list of sustainability indicators. Upon completion of the Initial Assessment, a preliminary list of sustainability indicators was identified and shared with City staff. Each indicator underwent a feasibility assessment based on contribution and importance to sustainability goals, as well as data availability and validity. The Indicator Assessment was an iterative process, in which data availability and constraints prompted additional research for indicator selection and refinement. Coordination with City staff from various agencies was critical to this process in order to collect expert feedback on which measures were most useful to city-wide goals. During a site visit to San Francisco in January 2020, I met with City staff to review available data and discuss importance of qualities for measurement.

Task 2 Deliverables:

- *Part II. Indicator Assessment*: in-depth written descriptions, research, and methodologies of indicators selected for the Dashboard

TASK 3: DATA ANALYSIS + VISUALIZATION

Datasets were collected from online sources (such as DataSF) and through coordination with City agencies, including San Francisco Planning, San Francisco Department of Environment (SFE), San Francisco Department of Public Health (DPH), and San Francisco Public Utilities Commission (SFPUC). An essential part of any data analysis project is data cleaning and preparation. Collected datasets were explored and cleaned (using Python) in order to evaluate data validity before undergoing analysis and visualization. Many of the datasets used needed to be modified or transformed in order to make the indicators useful to Dashboard users, which was done using Python and Esri ArcMap. The Dashboard was created in Tableau, a popular software for dashboards and data visualization.

Task 3 Deliverables:

- *Sustainable Neighborhood Dashboard*: an interactive dashboard prototype showing maps and indicators for the Framework's goals and targets
- *Part III. Sustainable Neighborhood Dashboard User Guide*: a quick snapshot of how to navigate and use the Dashboard
- *Geodatabase*: a geodatabase with final indicator datasets

PART I

INITIAL ASSESSMENT

The Initial Assessment seeks to investigate processes of data-driven sustainability assessment in order to take an informed approach to indicator selection and development of the Dashboard. The result of this research is a set of five (5) guiding principles that direct the Indicator Assessment process, as well as the creation of the Dashboard.

This initial assessment relies on primary and secondary sources in three (3) key areas: (i) preliminary assessment of San Francisco goals, policies, and programs to ascertain important factors for determining use of sustainability indicators; (ii) comprehensive review of the use of sustainability indicators in other cities; and (iii) review of literature on the use of urban sustainability indicators and urban analytical tools and dashboards.

LOCAL ASSESSMENT

SUSTAINABILITY METRICS SCAN

INDICATOR-BASED SUSTAINABILITY ASSESSMENT

URBAN INDICATORS AND ANALYTICS

LOCAL ASSESSMENT

A review of San Francisco goals, policies, and programs was undertaken to understand the local context for each of the Framework's five (5) goals and fifteen (15) targets, shown in Table 1. An understanding of existing requirements and goals is important to ensuring relevancy of selected indicators.

Table 1. Review of Existing San Francisco Requirements and Goals

- indicates goal * indicates requirement

GOAL	TARGET	EXISTING REQUIREMENTS/GOALS
HEALTHY AIR	ZERO-EMISSION environments	- Net-zero GHG emissions by 2050 [C40 Declaration] * Greenhouse Gas Emissions compliance checklist [CEQA] * Transportation Demand Management (TDM) plan for some new development [PC] * Bicycle parking/racks [PC] * 100% EV-ready off-street parking in new construction and major alterations [GBC] * EV chargers @ 10% of spaces for commercial lots with 100+ spaces [EC] - 100% emission-free ground transportation by 2040 [EV Roadmap] * All-electric preferred for new construction [GBC 20]
HEALTHY AIR	100% NON-TOXIC interiors	* Low-emitting materials for all new construction [GBC] * Enhance ventilation/filtration systems [Art. 38/Health Code] * Indoor Air Quality Management Plan for construction some new construction [GBC] * Flame-retardant free upholstered furniture and juvenile products [EC]
HEALTHY AIR	COMFORTABLE micro-climates	N/A
RENEWABLE ENERGY	Maximum energy EFFICIENT environments	* Increased efficiency requirements (10-28% over CA Title 24) for mixed-fuel new construction [GBC] * Existing Commercial Building Energy Performance Ordinance [EC]
RENEWABLE ENERGY	100% CARBON-FREE energy	- 100% renewable energy by 2030 [Ordinance 81-08] * 15% roof area installed with solar PV or solar thermal systems for new construction up to 10 occupied floors [BRO/GBC] * 100% renewable electricity purchase for commercial buildings 500k sf+ by 2022, 250k sf+ by 2024, 50k sf+ by 2030 [EC]

GOAL	TARGET	EXISTING REQUIREMENTS/GOALS
RENEWABLE ENERGY	SMART systems & operations	N/A
ROBUST ECOSYSTEMS	GREEN space equivalent to ½ site area	- 50,000 new street trees by 2035 [Urban Forest Plan] * 30% roof area as living roof for new construction up to 10 occupied floors, alternative compliance [BRO alt./PC] - 100% of residents within ¼ mile (5-minute) walk to green open space * 20% front set-back landscaped (50% pervious) [GLO/PC] * 1 street tree every 20' of ROW [GLO/PC]
	BIODIVERSE landscapes with a majority local species	- Biodiversity Policy goals (biologically rich, equitable access, stewardship, planning and design, resilience) [Res. 107-18] * Climate appropriate plantings [GLO/PWC]
	HEALTHY food & wildlife systems	- Biodiversity Policy goals (biologically rich, equitable access, stewardship, planning and design, resilience) [Res. 107-18] * Bird Safe Buildings [PC] * Restricted use of pesticides [Integrated Pest Management Ordinance]
CLEAN WATER	HIGH QUALITY waterways & sources	* 20% front set-back landscaped (50% pervious) [GLO/PC] * Required use of BMPs depending on project size [SMR] * Slowed stormwater flow rates [SMO] * Reduced runoff and pollution from construction [GBC] * (MS4) filter or treat 80% on site [SMO] * Manage 25% of stormwater onsite [SMO option]
	REGENERATIVE (minimize consumption & maximize reuse)	* Non-residential indoor water use reduction [GBC] * Residential multi-family water sub-metering [GBC/CA Water Code] * On-site systems for non-potable flushing and irrigation [Art. 12C/Health Code] * Low water, climate-appropriate plants [GBC]

GOAL	TARGET	EXISTING REQUIREMENTS/GOALS
CLEAN WATER	100% FLOOD-SAFE buildings & sidewalks	Sea level rise consideration [CEQA] * 100-year storm flood risk disclosure [Ord. 35-19/ Housing Code] * SLR vulnerability and risk assessment for structures/ land use changes within 100 ft [SF Bay Plan]
ZERO WASTE	100% RESPONSIBLE material use	* 65-75% recycling of construction and demolition materials [C&D Ordinance/EC]
	Refuse generation REDUCED by 15%	* Accessible and sufficient collection systems [EC] - Reduce disposal to landfill and incineration 50% by 2030 [C40 Declaration] - Reduce municipal solid waste generation by 15% by 2030 [C40 Declaration]
	100% materials RECOVERED from waste stream	- 100% diversion from landfill by 2020 [Res 002-03-COE] * Mandatory recycling and composting [EC]

This table was adapted from materials provided by San Francisco Planning. Additional goals/requirements were added to original version.

[EC]: San Francisco Environment Code
[CEQA]: California Environmental Quality Act
[PC]: San Francisco Planning Code
[GBC]: San Francisco Green Building Code
[BRO]: Better Roof Ordinance
[CCR]: California Codes and Regulations
[PWC]: San Francisco Public Works Code
[GLO]: Green Landscaping Ordinance
[SMR]: San Francisco Stormwater Management Requirements
[SMO]: Stormwater Management Ordinance

SUSTAINABILITY METRICS SCAN

Use of sustainability indicators in other cities is evaluated through a comprehensive survey of sustainability metrics, which is shown in Appendix A, and utilizes primary sources such as sustainability plans and frameworks from major U.S. cities, including OneNYC, pLAn (Los Angeles), Sustainable Chicago 2015, Boston Climate Action Plan, Seattle Climate Action Plan, and Sustainable D.C. 2.0. The Sustainability Metrics Matrix (Appendix A) is based on a draft provided by San Francisco Planning, and was used supplemented to record an updated list of indicators used by other cities organized by the Framework's five (5) goals. Research on other cities' metrics was used throughout the Indicator Assessment process to make informed decisions about indicator selection. The key takeaways from the Sustainability Metrics Matrix include:

- Most all cities measure sustainability performance at the city-wide level.
- Many cities define metrics in terms of actions or desired outcomes, rather than performance assessment indicators.
- Some cities do not align indicators with specific targets or use oversimplified target definitions, such as "Increase" or "Decrease" (OneNYC).
- Some cities set targets but do not define the indicators that will be used to track progress (Portland 2015 Climate Action Plan, Sustainable Chicago 2015).

INDICATOR-BASED SUSTAINABILITY

Sustainability assessments may be used to provide valuable inputs to strategic planning and decision-making, to share information for monitoring, evaluation, and analysis, and to raise awareness about sustainability.[13] Indicator-based sustainability assessments are increasingly used by cities with the objective of revealing the state of sustainability, making sustainability measurable and manageable, and assessing the impacts of sustainable development projects.[14] Sustainability indicators are useful tools for cities to communicate goals and progress, and integrate physical and social science knowledge into local decision-making. Indicators may lead to better decisions and actions by making simplified, aggregated information available to stakeholders.

Most operationalized sustainability indicator frameworks are oriented to the national, global, or city-wide level, highlighting the importance for new frameworks at the community and neighborhood level.[15] Neighborhood-scale sustainability assessment allows for assessment of environmental and social heterogeneities across cities, as well as an understanding of performance in relation to other neighborhoods. Increasingly, the neighborhood-scale is recognized as an opportunity to leverage innovative, systems-based solutions for sustainable development.[16] Neighborhood-scale sustainability lies at the intersection of comprehensive and purely localized approaches, and may be seen as the "sweet spot" between the building and the city.[16] Where it is not politically or economically feasible to implement technologies and policies at the city level, the neighborhood level offers an opportunity for innovation.

Neighborhood-level frameworks are instrumental to promoting projects that exceed city goals and requirements and amplify performance and co-benefits.

A number of neighborhood-scale models for sustainability have emerged in cities across North America during the past decade:

- LEED for Neighborhood Development (LEED-ND) was the first national system for neighborhood design, integrating principles of smart growth, urbanism and green building.[17]
- EcoDistricts and Green Zone Projects are performance frameworks to advance neighborhood-scale sustainability with considerable flexibility as to requirements and strategies.[18]
- 2030 Districts is a defined-model framework that identifies specific goals to be achieved within particular time frames and is targeted at private sector investment.[19]
- Regenerative Neighborhoods is an emerging framework that aims to move development beyond net-zero to net-positive.
- Other certification frameworks for district-scale sustainability include Living Building Challenge and Enterprise Green Communities.[20, 21]

Existing neighborhood-scale frameworks are critiqued for basing assessment off of inputs or activities perceived as sustainable solutions rather than long-term impacts (e.g. achieving LEED points rather than measuring impacts).[22] Other critiques include unbalanced focus on three pillars of sustainability, lack of local context, lack of cross-scale relationships, and lack of local adaptability and participation.[23, 24]

URBAN INDICATORS AND ANALYTICS

Dashboards are interactive tools that visualize data through maps, graphs, and other data visualizations to compare and monitor a variety of data simultaneously. Data dashboards are increasingly used by cities for evaluating and managing urban services, formulating policy, fostering public knowledge, and undertaking long-term planning. Though dashboards provide information in a quick and effective manner, they run the risk of over simplifying complex issues and reveal a number of shortcomings that need to be addressed. In addition to common issues around data availability, measurement, and literacy, indicator selection can be inherently political and necessarily partial and simplified.

Effective analytical tools must ensure that data is 'open', in that it can be freely used, accessed, and redistributed by anyone.[25] In this regard, successful dashboards should remain accessible, accurate, useful, understandable, and meaningful to the public. In addressing these concerns, there are critical steps that need to be considered in the development of a dashboard, including documentation of limitations with respect to the scope and accessibility of data, exploration of veracity and validity of datasets, and recognition of subjectivity.[26, 27]

GUIDING PRINCIPLES

Through this research, a list of five (5) Guiding Principles was established to inform the Indicator Assessment and creation of the Dashboard. The Guiding Principles represent best practices and judgement for urban sustainability assessment and analytics that should be considered for any data-driven sustainability project.

1 Integrate local knowledge and adaptability, ensuring that indicators are aligned with San Francisco's local context.

2 Identify indicators that can be used to comparatively assess environmental and social heterogeneities.

3 Document limitations in data availability and quality and provide recommendations for addressing limitation through improved reporting and cross-coordination.

4 Provide clear and concise information on methodologies, rationale, and potential use of indicators.

5 Refrain from claiming objectivity and highlight the need for analytical tools to be used in conjunction with other forms of knowledge and other modes of governance when making decisions.

PART II

INDICATOR ASSESSMENT

Effective evaluation of indicators is a critical pre-step. Data only becomes an indicator once its role in the evaluation process has been established. The Indicator Assessment process aimed to identify one performance indicator for each of the fifteen (15) targets. The selection of specific indicators required consideration of both the type of information that will best represent the targets and the availability and quality of data at the necessary geographic scale. Metrics were evaluated based on their ability to:

- Align with the Framework's 5 goals, 15 targets, and 3 critical imperatives;
- Be scalable to analyze performance from and within the neighborhood level;
- Be measurable using existing data;
- Be clear and intelligible, and reflect what it is intended to measure; and
- Be of sufficient quality and be complete, accurate, and current and/or recent.

GOAL 1: HEALTHY AIR

ENSURE NON-TOXIC & COMFORTABLE AIR INDOORS & OUT

TARGET 1: ZERO-EMISSION ENVIRONMENTS

Indicator: Ambient Air Quality
Measure(s): Average annual particulate matter concentration
Unit: Micrograms per cubic meter
Data: Particulate matter concentration (raster) – DPH/San Francisco Planning

Due to its geography, local weather patterns, and limited industrial activity, San Francisco has relatively better air quality in comparison to other cities, but concentrations of air pollutants around freeways, busier surface streets, and more industrial areas exceed public health standards.[28] Improving citywide air quality is a priority due to linkages with adverse health outcomes, namely adverse respiratory effects such as aggravated asthma, chronic bronchitis, and reduced lung function or heart and cardiovascular health. [28]

Both mobile and stationary sources make significant contributions to urban outdoor air pollution. According to the Bay Area Emissions Inventory, the primary sources of poor air quality in the city are mobile sources from cars, trucks, ships, and construction equipment.[29] San Francisco has increasingly fewer stationary sources of air pollution, as power plants in Hunters Point and Potrero Hill have closed and many industrial uses have left the city, though stationary sources such as diesel generators, gas stations, and dry cleaners continue to contribute to poor air quality.[29]

Particulate matter is a common proxy indicator for air pollution. Particulate matter (PM) is considered to have the highest health impacts of criteria air pollutants. Criteria air pollutant (carbon monoxide, lead, ground-level ozone, particulate matter, nitrogen dioxide, sulfur dioxide) emissions are generated by stationary, area-wide, and mobile sources. Stationary sources are usually associated with large manufacturing and industrial facilities. Area sources emit small amounts of pollutants individually (e.g. water heaters, painting operations). Mobile sources include on-road motor vehicles, aircraft, ships, or trains.

Toxic air contaminants (TACs) are not criteria pollutants, but include a diverse group of air pollutants which are associated with adverse health-related effects resulting from either acute or chronic exposure. Significant sources of TACs include industrial facilities, gasoline stations, dry cleaners, and buildings with boilers or emergency generators. Mobile sources are gasoline- and diesel-powered vehicles.

Methodology:
Particulate matter estimates were derived from the San Francisco Citywide Health Risk Assessment (Citywide HRA) analysis developed in 2020.[30] Article 38 of the San Francisco Health Code, established in 2008, requires new construction in areas with poor air quality to install enhanced ventilation systems to protect residents from health effects. To identify areas with elevated air pollutant concentration, DPH and San Francisco Planning oversee citywide health risk assessment modeling to map regions where exposure to air pollution is higher. The analysis uses air pollution dispersion modeling which applies a time-averaged, simplified representation of dispersion

GOAL 1: HEALTHY AIR

ENSURE NON-TOXIC & COMFORTABLE AIR INDOORS & OUT

of pollutants to input data of emissions estimates from major air pollution sources. Air pollutants considered in the analysis include emissions of PM 2.5 and primary TACs. Emissions estimates come from roadway activity developed from San Francisco Chained Activity Modeling Process and stationary and mobile sources evaluated by the Bay Area Air Quality Management District (BAAQMD). The most recent Citywide HRA was developed for a development year of 2020, which is an update to the prior development year of 2014.

The Citywide HRA evaluated source contributions at point locations on a receptor grid of 20 meters by 20 meters. Concentration of a pollutant at each receptor point location was calculated by multiplying the estimated annual average emissions of the pollutant by the dispersion factor for the source. San Francisco Planning's Environmental Planning division shared the estimated PM 2.5 concentration grid. The grid was converted from point features to a raster dataset using the Point to Raster tool from the Esri Conversion toolbox. In doing so, the total PM 2.5 concentration (sum of traffic, stationary, railway, maritime, and background emissions) value for each point was assigned to the output raster cells. The resulting raster layer shows the annual average PM 2.5 from all modeled sources and background concentrations throughout San Francisco in 2020.

PM 2.5 concentrations values for each neighborhood boundary and census tract were calculated using the Zonal Statistics as Table tool from the Esri Spatial Analyst Toolbox, which summarizes the raster cells within designated zones (i.e. neighborhood boundaries and census tracts). The resulting summary statistics tables were appended to the neighborhood and census tract boundary polygons using a table join.

Limitations:
Displaying the mean PM 2.5 concentration for each neighborhood does not take into account the differences with the neighborhood. When aggregating to a larger geography, the data becomes coarser. Evaluating PM 2.5 concentration by neighborhood may be used as a stop-light measure to analyze overall neighborhood trends and trajectories, however, more granular data should be used to evaluate differences within the neighborhood boundary.

Some emissions sources are not included in the HRA analysis because they are either too difficult to analyze, were judged to be less important, or are temporary or intermittent sources. These include: residential wood burning from fireplaces and wood stoves; commercial and residential cooking; indirect sources that generate vehicle trips such as distribution centers, retail centers, and postal service stations; and construction emissions.[30]

GOAL 1: HEALTHY AIR

ENSURE NON-TOXIC & COMFORTABLE AIR INDOORS & OUT

TARGET 2: 100% NON-TOXIC INTERIORS

Indicator: Indoor Air Quality Sources
Measure(s): Cases of indoor air pollutant sources
Unit: Number of cases of indoor air pollutant sources
Data: Violations issued by the Department of Building Inspection (table) - Open DataSF
California Air Toxics "Hot Spots" Program Facilities (table) - CARB

In the last several years, a growing body of scientific evidence has indicated that the air within homes and other buildings can be more seriously polluted than the outdoor air in even the largest and most industrialized cities.[31] Further, unlike ambient (outdoor) air pollution, which disperses from wind, indoor air is usually stagnant. Other research indicates that people spend approximately 90 percent of their time indoors. For many people, the risks to health may be greater due to exposure to air pollution indoors than outdoors. Poor indoor air quality may be caused by either indoor air pollution sources or outdoor air pollution sources.

In the last several years, a growing body of scientific evidence has indicated that the air within homes and other buildings can be more seriously polluted than the outdoor air in even the largest and most industrialized cities. Further, unlike ambient (outdoor) air pollution, which disperses from wind, indoor air is usually stagnant. Other research indicates that people spend approximately 90 percent of their time indoors. For many people, the risks to health may be greater due to exposure to air pollution indoors than outdoors. Poor indoor air quality may be caused by either indoor air pollution sources or outdoor air pollution sources.

There are many sources of indoor air pollutants which emit a wide variety of air pollutants depending on the materials and fuels used within the building as well as the type of human activity. Common sources of indoor air pollution include fuel-burning combustion appliances, use of tobacco products, building materials and furnishing, products for household cleaning and maintenance/personal care, central heating and cooling systems, and excess moisture and mold. Primary sources of indoor air pollution, defined by the Environmental Protection Agency, include: asbestos; biological pollutants; carbon monoxide; formaldehyde/pressed wood products; lead; nitrogen dioxide; pesticides; radon; indoor PM; secondhand smoke/environmental tobacco smoke; stoves; heaters; fireplaces; and chimneys, and volatile organic compounds (VOCs).[32]

Methodology:
This indicator uses available data to measure where disproportionate indoor air quality sources are located. The California Air Toxics "Hot Spots" Program requires stationary sources to report the types and quantities of certain substances routinely released into the air in order to collect emissions data.[33] The most recent inventory of stationary sources is used and analyzed to determine stationary sources that emit primary indoor air pollutants. Of the indoor air pollutant sources defined by the EPA, the program records carbon monoxide, formaldehyde, and some VOCs

GOAL 1: HEALTHY AIR

ENSURE NON-TOXIC & COMFORTABLE AIR INDOORS & OUT

(benzene, and methylene chloride). PM is not included in this analysis because primary sources of PM are already measured as part of ambient air quality measures and less is known regarding the causes and effects of indoor PM. California Air Resources Board's (CARB) Facility Search Tool was used to download 2017 criteria and toxic air pollutant data for San Francisco County and select facilities with recorded release of carbon monoxide, formaldehyde, benzene, and methylene chloride.[34]

Department of Building Inspection (DBI) Records data is used to find housing violations with lead, asbestos, or mold. Violation data was cleaned in order to extract violations from 2019 that contained "lead", "asbestos", or "mold". There were 231 cases of mold and 602 cases of lead in 2019. Though there are historical cases of asbestos (as recent as 2018) in San Francisco, there were no records for 2019. Two tables were imported into ArcMap—one with facilities from the California Air Toxics "Hot Spots" Program and one with the filtered DBI inspection records. The tables were geocoded as point locations and combined into one dataset using the Merge tool.

Limitations:
Indoor air pollution sources are based both on the toxicity of materials used for interiors and personal activities, making it difficult to track and measure on a larger scale. There are a wide variety of other indoor air pollutants that are not being measured, particularly pollutants from household products and habits. Tracking these pollutants would require indoor air monitoring tests and cannot be tracked at the citywide scale.

TARGET 3: COMFORTABLE MICRO-CLIMATES

Indicator:	Urban Heat Island Exposure
Measure(s):	Average Surface Temperature
	Air Quality
	Tree Canopy
	Housing Age
	Population Density
Unit:	Exposure Score
Data:	Particulate matter concentration (raster) – DPH/ San Francisco Planning
	Land Use (shapefile) – San Francisco Planning
	Urban Tree Canopy (shapefile) – San Francisco Planning

Several factors are known to cause urban heat island (UHI). Paved surfaces, such as roads and parking lots, or dark surfaces, such as rooftops, absorb solar radiation as heat. Cities also contain anthropogenic heat sources, including thermal mass of buildings and waste heat generated from industrial processes and mechanical air conditioning. Temperature differentials occur within the urban environment based on these factors, meaning the average surface temperature of one neighborhood may be significantly different to an adjacent neighborhood.

GOAL 1: HEALTHY AIR

ENSURE NON-TOXIC & COMFORTABLE AIR INDOORS & OUT

Two primary indicators are often used to measure UHI—air temperature and land surface temperature.[35] Air temperatures are a direct UHI measure, but they are only available for single measurement stations. Land surface temperature can account for temperature distribution, but it is only an indirect estimate of the UHI.

Urban heat island vulnerability may be measured, in part, by the degree of exposure to extreme heat. Exposure may be influenced by weather and climatic conditions, land use and the environment, vegetation, and quality of housing and infrastructure. Exposure, here, is measured through an index including air quality (using PM 2.5 concentrations as a proxy measure), urban tree canopy coverage, housing age, average surface temperature, and population density. Extreme heat is associated with poor air quality. When high temperatures coincide with periods of high atmospheric pressure, ozone and PM can reach high levels. Tree canopy coverage is an important indicator for exposure, as trees provide shade and can facilitate evaporation. Majority of the health impacts from extreme heat occur indoors. Housing age is used as a proxy measure for air conditioning use, which is an important indicator of exposure as older homes are less likely to have air conditioning or cooling capacity.

Methodology:
The UHI exposure index uses four measures which are inputted into a multi-decision criteria analysis to determine areas with higher exposure risk. First, the data for the four measures was prepared, as detailed below. The raster data for the four measures were then used as decision layers in a multi-criteria decision analysis. The resulting decision raster data was aggregated to the census block and neighborhood levels

Average surface temperature was derived from aerial imagery data taken during the 2017 Labor Day Extreme Heat Event. The raster data was reclassified into four categories, 1 for less than 100°, 2 for 100° to 110°, 3 for 111° to 116°, and 4 for greater than 117°. The PM 2.5 concentration raster, an output from the analysis for Target 1, was used again here as a proxy for ambient air quality. The raster was reclassified into four categories, 1 for up to 7.99 ug/m3, 2 for 8 to 8.99 ug/m3, 3 for 9 to 9.99 ug/m3, and 4. for greater than 10 ug/m3. The urban tree canopy (UTC) polygon was acquired from DataSF. In preparation for the San Francisco Urban Forest Plan (2013), the Planning Department performed an UTC Analysis using aerial imagery to determine a canopy estimate for the City & County of San Francisco. The UTC layer was dissolved into one feature class and converted to raster. The raster UTC data was then reclassified into two categories, 0 for UTC and 1 for non-UTC. Housing age was derived from the Planning Department's land use dataset, which has a field for year built. Average building age for each census block was calculated using Zonal Statistics as a Table, which was then appended to census block boundary polygons. The polygons were converted into raster data, using average building age as the value classification. The raster data was reclassified into four categories, 1 for 2000 to 2020, 2 for 1974 to 2020, 3 for 1941 to 1973, and 4 for pre-1940.

Limitations:
Measuring ULI from land surface temperature does not consider the differences in experienced

GOAL 1: HEALTHY AIR

ENSURE NON-TOXIC & COMFORTABLE AIR INDOORS & OUT

localized temperature. It also yields a fairly similar result to doing an impervious surface analysis, with impervious areas showing hotter temperatures. While land surface temperature gives us a general idea of how hot a certain area is, temperatures tend to be much hotter than what we actually feel. Ambient air temperature measurements would be more effective to capture San Francisco's microclimates, allowing us to more accurately assess the potential health impacts associated with extreme heat. Ambient air temperature could be measured in more locations by deploying sensors. Boston, Cambridge, and Brookline, in partnership with the Museum of Science, Boston, deployed air temperature sensors on cars to calculate granular air temperature distribution. This project is discussed further in the *Recommendations* section.

GOAL 2: RENEWABLE ENERGY

ACHIEVE AN EFFICIENT & FOSSIL FUEL-FREE ENVIRONMENT

TARGET 4: MAXIMUM ENERGY EFFICIENT ENVIRONMENTS

Indicator: Average Energy Usage (Non-residential, Residential)

Measure(s): Average Site Energy Use Intensity (Non-residential)
Average Energy Use per Capita (Residential)

Unit: kBTUs/square feet
kBTUs/person

Data: PG&E 2019 Electricity Usage by Zip Code Data (Q1, Q2, Q3, Q4) (csv) – PG&E
PG&E 2019 Gas Usage by Zip Code Data (Q1, Q2, Q3, Q4) (csv) – PG&E
Land Use (shapefile) – San Francisco Planning
Total Population,2017 ACS 5-year estimates (csv) – U.S. Census Bureau
HUD-USPS ZIP Crosswalk (csv) – HUD

In 2017, buildings were responsible for 44 percent of citywide emissions.[36] Most building emissions come from the use of natural gas for water heating and space heating and cooling. Commercial and residential buildings contribute almost equally, with 51 percent from residential buildings (46 percent from natural gas and 5 percent from electricity) and 49 percent from commercial buildings (36 percent from natural gas and 13 percent from electricity).[36] Opportunities for emissions reductions come in the form of conservation, building efficiency measures, and electrification. Energy use intensity (EUI), annual energy consumption on site divided by gross floor area, is a commonly used metric to evaluate non-residential building energy performance. Site EUI is the annual energy consumption on site divided by gross floor area. Energy use per capita is a commonly used metric to evaluate residential energy performance.

Methodology:
PG&E provides non-confidential, aggregated energy usage data on a quarterly basis, available for public download. Customer usage data, both for gas (therms) and electric (kWh) usage, is reported by zip code, by month, by year, and by the four customer types – residential, commercial, agricultural, and industrial. Non-residential usage is comprised of commercial and industrial uses. Agricultural uses were not considered in this analysis, as they are considered negligible in comparison to residential, commercial, and industrial energy usage. Electricity and gas usage data were downloaded for 2019 Q1, Q2, Q3, and Q4, as separate csv files. The csv files were merged and converted to kBTUs (1 kWh = 3.412 kBTUs; 1 therm = 99.9761 kBTUs) in order to evaluate electric and gas usage together.

HUD's Office of Policy Development and Research releases USPS Crosswalk Files that enable ZIP code level data to be combined with census geography levels. The Crosswalk for ZIP-TRACT was used to allocate ZIP code level energy usage data to census tracts. The residential ratio was used for residential energy usage and the business ratio was used for commercial energy usage. The USPS Crosswalk ratios were merged with the energy usage data in order to convert ZIP code level energy usage data to the census tract level. Average energy use per capita was calculated

GOAL 2: RENEWABLE ENERGY

ACHIEVE AN EFFICIENT & FOSSIL FUEL-FREE ENVIRONMENT

for residential usage by appending the American Community Survey 5-year estimate population counts per census tract to the residential energy usage data frame and dividing the total residential usage (in kBTUs) by the total population (in number of people). The data was appended to the census tract boundaries using a table join.

Census tracts were aggregated to the Analysis Neighborhood boundaries by using the dissolve tool, specifying to include the sum for the energy usage field (kBTUS) and population for each neighborhood. A new field was added to the attribute table to calculate the energy usage per capita per neighborhood (kBTUs/person).

Average energy use intensity is calculated for non-residential usage by dividing the total non-residential usage (in kBTUs) by the total commercial building area (in square feet). Total commercial building area was calculated using the land use table by taking the sum of all non-residential use building area: CIE (Cultural, Institutional, Educational), MED (Medical), MIPS (Office), MIXED (Mixed Uses without Residential), PDF (Industrial), RETAIL/ENT (Retail, Entertainment), and VISITOR (Hotels, Visitor Services). Mixed use buildings (MIXRES) are included in the analysis by subtracting the residential area from the sum of all commercial area.

To calculate the total commercial building area within each census tract, the land use file was merged with the census tract boundaries using a spatial join with a merge rule to calculate the sum of building area within each boundary. Commercial energy data was appended to the polygons using a table join, after which a new field was added to calculate energy use intensity (in kBTUs/sf). The new census tract boundaries were then aggregated to the neighborhood boundaries using the dissolve tool, yielding the sum of energy usage and building area for each neighborhood. A new field was added again to calculate the energy usage intensity per neighborhood (in kBTUs/sf).

Limitations:
Data coverage varies for residential versus non-residential uses due to PG&E's data privacy restrictions. To meet confidentiality requirements there must be a minimum of 100 residential customers and 15 non-residential customers with no single non-residential customer accounting for more than 15% of the total consumption. For residential electricity usage, data is available for the majority of the city except for Presidio (94129) and Treasure Island (94130). For residential gas usage, data is available for the majority of the city except for Treasure Island (94130) and Mission Bay (94158). For non-residential electricity usage, data is missing for Outer Richmond (94121), Outer Sunset (94122), Presidio (94129), Treasure Island (94130), and parts of Glen Park and Midtown Terrace (94131). For non-residential gas usage, data is missing for Presidio (94129), Treasure Island (94130), parts of Glen Park and Midtown Terrace (94131), parts of Portola and Visitacion Valley (94134), and Mission Bay (94158).

Within the context of a neighborhood, more granular energy usage data would be more informative. PG&E may share granular energy usage data through the Energy Data Request Program (EDRP). EDRP was established in 2014 by California Public Utilities Commission

GOAL 2: RENEWABLE ENERGY

ACHIEVE AN EFFICIENT & FOSSIL FUEL-FREE ENVIRONMENT

14-05-016 and requires utility companies to provide access to energy usage data to researchers and government agencies, under limited use cases. In the development of the Sustainable Chinatown Initiative, the Sustainable Chinatown Steering Committee worked closely with the EDRP over a 15-month period to acquire energy consumption data for 2013-2014 for Chinatown at a census block level.[37]

TARGET 5: 100% CARBON-FREE ENERGY

Indicator: Solar Potential & Existing Solar Installations
Measure(s): Solar potential per household
Installed solar capacity per neighborhood
Unit: kWh/year
Data: Solar potential per census tract (table) - Google Project Sunroof
Interconnected solar data set (table) - CA Distributed Generation Statistics

The City's CAS outlines opportunities to reduce emissions and puts forth the goal of 100 percent renewable energy.[38] In 2017, electricity supplied to all customers was 82 percent emissions-free, with 64 percent of electricity generated from renewable sources including wind, solar, and large hydropower. Buildings participating in CleanPowerSF, San Francisco's Community Choice Aggregation program, are powered by 100 percent emissions-free electricity. GoSolarSF, SFPUC's solar installation incentive program, has provided incentives for installation of 26.3 MWh in solar systems from 2008 to 2020 across San Francisco, which is enough to power 19,725 homes. Additionally, SFPUC has installed solar to 23 city owned buildings which generates approximately 8.6 MWh of renewable energy in San Francisco.

San Francisco's GBC has robust requirements for renewable energy, requiring solar panels or solar heating in the solar ready zones defined by the California Building Energy Efficiency Standards Title 24.[39] Though there are a variety of methods that could be used to calculate solar potential, there are a number of existing models and tools that allow for easy calculation of solar potential by building.

Mapdwell uses a Solar Access Index (SAI), ranging from 0 to 1, defining high potential as 0.8 or greater and based on a 18% efficiency panel.[40] Google Project Sunroof estimates the technical solar potential, or the amount of energy that the building can generate irrespective of financial or societal constraints, of all buildings for a region specified by the user and has wider geographic coverage than Mapdwell.[41] Project Sunroof's model assumes each panel to be 250W with an efficiency of 15.3 percent and arrays to be between 2 kW and 1,000 kW.

For existing solar capacity, attempts were made to acquire existing solar installation data aggregated to the census block or census tract from SFE, SFPUC, and PG&E, however, there is no comprehensive solar installation database for San Francisco available for public use at the census

GOAL 2: RENEWABLE ENERGY

ACHIEVE AN EFFICIENT & FOSSIL FUEL-FREE ENVIRONMENT

block or census tract level. SFPUC tracks installations that go through their GoSolarSF Program and was only able to provide city-wide aggregated data. DBI electrical permit data was analyzed in an attempt to extract a database of existing installations. Permit data has human-written descriptions, however, making it difficult to extract information about the solar panel capacity and whether the panel is being installed or maintained. California Distributed Generation Statistics (CDGS), who publishes investor-owned utility solar PV net metering interconnection data, maintains a monthly updated dataset that provides all interconnected solar PV systems (excluding pending and decommissioned) that is available for public use aggregated at ZIP code level.

Methodology:
The analysis uses data from Google Project Sunroof, rather than Mapdwell, because Google Project Sunroof allows for data exportation down to the census tract level. The data was exported at the census tract level and appended to census tract boundaries in ArcMap using a table join. Total solar energy generation potential for all roof space was aggregated to Analysis Neighborhood boundaries by using the dissolve tool, specifying to include the sum for solar potential (kW). The CDGS dataset, which includes interconnected solar PV system capacity aggregated at the ZIP code level, was added to ArcMap and appended to ZIP code boundaries using a table join.

Limitations:
Evaluating solar potential at the neighborhood- and census- tract level may enable efficient resource allocation, but cannot be used for building-level decision making. Users may want to use Google Project Sunroof or Mapdwell to do so. Within the context of a neighborhood, more granular renewable energy installation data would be more informative. Previous attempts at building solar project databases have relied on voluntary surveys and self-reporting, and have led to little success (OpenPV). In 2018, researchers at Stanford University created DeepSolar, a deep learning framework that analyzes satellite imagery to identify the GPS locations and sizes of solar photovoltaic (PV) panels throughout the U.S.[42]

TARGET 6: SMART SYSTEMS OPERATIONS

Indicator: *No indicator selected*

To support grid optimization, it is important that energy efficiency and renewable energy measures are combined with smart time-of-use devices and energy storage solutions. Smart systems and operations are an important step to achieving a more reliable and efficient electric grid. Systems may enable smarter choices about energy consumption, more accurate time-of-use energy charges, and faster responses to outages and other service problems. Smart systems technology includes programmable thermostats, smart meters, occupancy sensors, and energy management systems. Multiple indicators were explored, including installation of smart meters and battery energy storage, however, no available data was found.

GOAL 3: ROBUST ECOSYSTEMS

SUPPORT BIODIVERSITY & CONNECT EVERYONE TO NATURE DAILY

TARGET 7: GREEN SPACE EQUIVALENT TO HALF THE SITE AREA

Indicator: Green space provision
Measure(s): Percentage of vegetated land
Unit: Percentage of land
Data: Normalized Difference Vegetation Index (raster) – SFPUC

There are many environmental and social benefits to urban green spaces and vegetation. Urban green spaces play a positive role in rainwater-runoff and urban flooding reduction. Use of green space for urban water management increases adaptive capacity along with coping capacity (by slowing down runoff during a heavy rainfall event), threshold capacity (by storing water to prevent heat stress), and recovery capacity (by providing infiltration after flooding).[43] Urban vegetation can directly and indirectly affect local and regional air quality through temperature reduction and microclimatic effects, filtering of pollutants and emissions, and reducing building energy use. Vegetation is important to regulating local air temperatures and extreme heat. Higher proportion of green cover in urban areas can mitigate urban warming and reduce negative health and energy consumption consequences of high urban temperatures.[44] Evapotranspiration from vegetation and shading can decrease energy use for heating and air conditioning in urban areas through additional shading and reducing wind speed.[45]

Accessibility is also an important measure of urban green space. San Francisco became the first city in the country where all residents live within a 10-minute walk to a park.[46] The 10-minute walk catchment is considered a reasonable distance for accessing public parks and is the distance that Trust for Public land applies in their rating system for parks. Because San Francisco achieved this goal and this is a well-researched indicator, green space accessibility was not used as an indicator.

Methodology:
SFPUC recently used 2018 aerial imagery data to create a Normalized Difference Vegetation Index (NDVI) analysis, which uses remote sensing to classify vegetation, which was acquired for further analysis. The NDVI's raster values ranged from 1 to 200, which were reclassified into two classes based on value—1 to 100 for non-vegetated surfaces and 101 to 200 for vegetated surfaces. This resulted in a thematic raster dataset classified into non-vegetated and vegetated surface areas. Two separate raster layers were extracted for each classification using the Extract by Attribute tool from the Spatial Analyst Toolbox.

Analysis Neighborhood and census block boundaries were converted from polygons into raster files. The total area of vegetated surfaces was calculated for each neighborhood and census block using the Tabulate Area tool from the Spatial Analyst Toolbox. The resulting tables were appended to the Analysis Neighborhood and census block boundaries using a table join. New fields were added to calculate the percentage of vegetated surfaces within each zone.

Limitations:
Measuring total percentage of land area covered by

GOAL 3: ROBUST ECOSYSTEMS

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green space does not take into account the distribution. When aggregating the percentage to a larger geography, the indicator may become less useful for understanding localized distribution of green space and its associated benefits. For instance, the area comprising Golden Gate Park would yield a high percentage of green space even if the surrounding area was highly impervious.

Evaluating green space coverage by neighborhood may be used as a stop-light measure to analyze overall neighborhood trends and trajectories, however, more granular data should be used to evaluate differences within the neighborhood boundary. Census block level data is also shown in the Dashboard to discern these differences.

TARGET 8: BIODIVERSE LANDSCAPES OF MAJORITY LOCAL SPECIES

Indicator: Plant Species Richness
Measure(s): Total species richness
Native species richness
Unit: Number of unique species
Data: iNaturalist observations (table) - iNaturalist

Biodiverse urban landscapes should include a diverse mix of species, as well as use of climate appropriate and native species, in the urban tree canopy, understory plantings, natural areas, or building facades. Traditionally, urban areas have been viewed as locations of low biodiversity that are dominated by non-native species. Urbanization reduces biodiversity by increasing the importation of non-native species; native species restoration is critically important to restoring biodiversity in urban areas.[47] Climate-appropriate species may also improve water efficiency, reducing the need for maintenance.

SFE and RPD are working with the Presidio Trust and the California Academy of Sciences to create a comprehensive method for measuring and tracking species and ecosystem health in San Francisco. The City will set species, ecological community and ecosystem targets, and incorporate them into a comprehensive citywide biodiversity and ecosystems restoration strategy, which would provide the scientific framework for implementing the City's Biodiverse City Vision. Currently, the City is primarily focused on presence-absence data collection and evaluation in natural areas and parks.

This analysis broadens the analysis to provide an evaluation of biodiversity throughout the entire City. Species richness is a fundamental measurement of community and regional diversity, and it underlies many ecological models and conservation strategies. This analysis uses data from iNaturalist, a citizen science application housed at the California Academy of Sciences, because it is the largest and most accessible biodiversity database in the world that allows data collection for any species.

Methodology:
iNaturalist observations in San Francisco between

GOAL 3: ROBUST ECOSYSTEMS

SUPPORT BIODIVERSITY & CONNECT EVERYONE TO NATURE DAILY

the years 2015 and 2019 were exported from the iNaturalist tool as a csv file. The observation data was compared to a native plant list prepared by members of the California Native Plant Society (Yerba Buena Chapter), which was obtained from SFE. California native plant observations were extracted into a separate data table. The observation data table was added to ArcMap and geocoded as point locations using the latitude and longitude fields. Using a spatial join, the neighborhood boundaries to the observation points in order to allocate a neighborhood to each point. Summary statistics for each neighborhood were calculated to find the frequency and sample size of each species within each neighborhood boundary.

Limitations:
There are socioeconomic limitations associated with using citizen science observations. iNaturalist data, though comprehensive for San Francisco, is not equal to biodiversity. Citizen science data is inherently social. The distribution of observations across the landscape of a city depend largely on who is making observations and where they are making them. Though imperfect, this tool can be used as a baseline to build upon and serve as a broader neighborhood indicator to foster community partnerships and promote greater equity in citizen science and urban biodiversity. Future iterations may be used to measure the percent change in biodiversity loss.

TARGET 9: HEALTHY FOOD AND WILDLIFE SYSTEMS

Indicator: Bird Species Richness
Measure(s): Bird species richness
Unit: Number of unique species
Data: EBird observations (table) - EBird

Urban wildlife studies often use birds as bio-indicators for understanding the health of urban wildlife and habitat because they are easier to count and they are more broadly familiar to the general public.[48,] The indicator uses EBird because it is the largest and most accessible bird observation database in the world that allows for data collection by anyone for any bird species.

Methodology:
EBird observations in San Francisco for year 2019 was exported from the EBird tool as a csv file. Only one year is selected due to the large sample size (97,403 observations). The observation data table was added to ArcMap and geocoded as point locations using the latitude and longitude fields. Using a spatial join, the neighborhood boundaries to the observation points in order to allocate a neighborhood to each point. Summary statistics for each neighborhood were calculated to find the frequency and sample size of each species within each neighborhood boundary.

Limitations:
There are socioeconomic limitations associated with using citizen science observations. Citizen

GOAL 3: ROBUST ECOSYSTEMS

SUPPORT BIODIVERSITY & CONNECT EVERYONE TO NATURE DAILY

science data is inherently social. The distribution of observations across the landscape of a city depend largely on who is making observations and where they are making them. Though imperfect, this tool can be used as a baseline to build upon and serve as a broader neighborhood indicator to foster community partnerships and promote greater equity in citizen science and urban biodiversity. Future iterations may be used to measure the percent change in biodiversity loss.

GOAL 4: CLEAN WATER

MAXIMIZE CONSERVATION, FLOOD PROTECTION & WATERSHED HEALTH

TARGET 10: HIGH QUALITY WATERWAYS AND SOURCES

Indicator: Impervious Surfaces
Measure(s): Percentage of land covered by impervious surfaces
Unit: Percentage of land
Data: Normalized Difference Vegetation Index (raster) – SFPUC

Level of impervious surfaces is a commonly used indicator for assessing water quality and is the recommended metric by NOAA.[49] Impervious cover results in multiple stressors to local watersheds, including increased pollutant loads from stormwater runoff, altered stream flow, decreased bank stability, and increased water temperatures. Sensitive water bodies can be impacted by as little as 5 to 10 percent impervious surface area, with greater impairments expected when rates exceed 20 to 25 percent.[50] Thresholds are considered higher for urban areas, as it would be unreasonable to argue that every watershed with 20 percent imperviousness was degraded and that urban development should consist only of low-density subdivisions.[50]

Methodology:
SFPUC recently used 2018 aerial imagery data to create a Normalized Difference Vegetation Index (NDVI) analysis, which uses remote sensing to classify vegetation, which was acquired for further analysis. The NDVI's raster values ranged from 1 to 200, which were reclassified into two classes based on value—1 to 100 for impervious surfaces and 101 to 200 for pervious surfaces. This resulted in a thematic raster dataset classified into impervious and pervious surface areas. Two separate raster layers were extracted for each classification using the Extract by Attribute tool from the Spatial Analyst Toolbox.

Analysis Neighborhood and census block boundaries were converted from polygons into raster files, in order to be used in the analysis. The total area of impervious surfaces was calculated for each neighborhood and census block using the Tabulate Area tool from the Spatial Analyst Toolbox. The resulting tables were appended to the Analysis Neighborhood and census block boundary polygons using a table join. New fields were added to calculate the percentage of impervious surfaces within each zone.

Limitations:
Imperviousness is considered to be the most irreversible land cover changes.[51] Measuring the percentage of impervious surface within an urban area should not necessarily be used to evaluate quality thresholds but, rather, to ensure impervious surfaces are not increasing significantly over time. Mapping impervious surface dynamics should focus on where newly emerged impervious surfaces are occurring over time.

Measuring the total percentage of land area covered by impervious surfaces does not take into account the distribution of impervious surfaces. When aggregating the percentage to a larger geography, the indicator may become less useful for understanding localized sources of runoff. For instance, the area comprising Golden Gate Park would yield a low percentage of impervious surfaces even if the surrounding area was highly

GOAL 4: CLEAN WATER

MAXIMIZE CONSERVATION, FLOOD PROTECTION & WATERSHED HEALTH

impervious. Evaluating impervious surface coverage by neighborhood may be used as a stop-light measure to analyze overall neighborhood trends and trajectories, however, more granular data should be used to evaluate differences within the neighborhood boundary. The original raster data is, thus, shown for each neighborhood profile.

TARGET 11: REGENERATIVE SYSTEMS (MINIMIZE CONSUMPTION & MAXIMIZE REUSE)

Indicator: Water Reuse
Measure(s): Water reuse system installations
Unit: Number of installations
Data: Plumbing permits (table) - DBI/Data SF

With an average residential per capita use around 43 gallons per person per day, San Francisco already exceeds the state's residential per capita reduction target of 55 gallons per person per day, dropping to 50 gallons by 2030. Increasing pressure on water resources, however, has led to a growing demand for alternative water sources. Onsite non-potable water reuse is a solution for communities to recycle and reuse water for non-potable purposes. In 2012, the City adopted the Onsite Water Reuse for Commercial, Multi-family, and Mixed Use Development Ordinance, commonly known as the Non-Potable Water Ordinance, which added Article 12C to the San Francisco Health Code, allowing for the collection, treatment, and use of alternate water sources for non-potable applications in individual buildings and at the district-scale.[52] In July 2015, Article 12C became a mandatory requirement for all new construction of 250,000 square feet or more of gross floor area. Each project implementing a non-potable water system must obtain a plumbing permit from DBI.

Methodology:
Plumbing permit records from DBI were obtained from DataSF. Records with information about water reuse installations were extracted, by selecting records for which the permit description included "rainwater", "reuse", "alternate water", "purple pipe", or "purple". The results were further analyzed to assess appropriateness of search parameters. A number of permit records were not indicative of an alternate water system installation. For example, the search yielded permit descriptions containing "rainwater leader", which is a pipe that takes water from the roof and gutters and drains it further away from the building. Incorrect records were removed accordingly.

The table of filtered plumbing permit records were geocoded as point locations using an address locator in ArcMap. Using a spatial join, the neighborhood boundaries were appended to the permit points in order to allocate a neighborhood to each point. Summary statistics for each neighborhood were calculated to find the frequency installations within each neighborhood boundary.

Limitations:
Numerous attempts were made to acquire granular water usage data (at geographies ranging from the census block level to the ZIP code level, as well as water reuse installation and capacity data) from SFPUC. SFPUC shared the average daily water use

GOAL 4: CLEAN WATER

MAXIMIZE CONSERVATION, FLOOD PROTECTION & WATERSHED HEALTH

per capita value for the entire city. Due to these factors, as well as the fact that San Francisco has relatively lower water consumption rates, water usage was not selected as an indicator. Water usage tracking could be improved through amending Existing Buildings Energy Performance Ordinance (Energy Code Chapter 20) to include a water usage benchmarking requirement. New York, Los Angeles, Boston, and Cambridge require water reporting and disclosure along with energy.

The plumbing permit dataset does not include any information about the size or capacity of alternate water systems being installed. Thus, it is difficult to gauge the true impact of these systems from this dataset. The location of alternate water systems, detached from size or capacity, may still be used to evaluate areas that are seeing more installations of alternate water systems. It is possible that permit data only covers non-potable water projects that are subject to Article 12C and, thus, may be undercounted.

TARGET 12: 100% FLOOD-SAFE BUILDINGS AND SIDEWALKS

Indicator:	Permanent and Temporary Flood Risk
Measure(s):	Permanent inundation (36”, 66”, 108”)
	Temporary 100-year storm runoff flood risk
Unit:	Percentage of area within flood zone
Data:	100-Year Storm Flood Risk Map (raster) – SFPUC
	Bay Area SLR and Shoreline Analysis (geodatabase) - Adapting to Rising Tides

Two distinct impacts can occur from sea level rise (SLR) and storm surge, or a combination of both—permanent inundation and temporary flooding. Permanent inundation occurs when an area is regularly covered by daily tidal fluctuations. San Francisco uses the National Research Council’s (NRC) most likely SLR projection of 36” for ongoing planning and development purposes related to environmental review and project approvals.[53] The SLR Action Plan considers adaptive strategies to address the NRC’s upper end estimate of 66” of SLR by 2100 in the event that future impacts accelerate beyond current predictions. Any project within the SLR Vulnerability Zone, which shows 83 inches of SLR with 100-year storm surge, is required to consider SLR vulnerabilities within the planning process and complete a “Sea Level Rise Checklist”.[54] According to the Guidance for Incorporating Sea Level Rise into Capital Planning, projects may choose to plan for the higher range, 83 inches by 2100, for assets that must maintain functionality if inundated. For other projects it is more appropriate to plan for the most likely scenario of 33 inches by 2100.[53]

Temporary flooding occurs when an area is exposed to short-term, extreme tide events (such as storm surge or El Niño events). As sea levels rise, assets become increasingly vulnerable to tide levels caused by extreme tide events. Assets that are currently vulnerable to temporary flooding from 100-year coastal flooding may be assessed with SFPUC’s Flood Map. With San Francisco’s hilly topography, storm runoff flows often still flow the naturally-formed historical waterways which can result in property damage. SFPUC developed a

GOAL 4: CLEAN WATER

MAXIMIZE CONSERVATION, FLOOD PROTECTION & WATERSHED HEALTH

100-Year Storm Flood Risk Map that shows areas of San Francisco that are highly likely to experience deep and contiguous flooding from storm runoff during a 100-year storm. The Flood Map only shows temporary flood risk from storm runoff; it does not consider flood risk from permanent inundation from the San Francisco Bay or Pacific Ocean.

Methodology:
The map incorporates the different scenarios as separate layers that the user can toggle between. Enabling multiple layers of flood risk allows the user to understand risks from both permanent inundation and temporary flooding, which may require different interventions. The three flood raster layers were imported into ArcMap, converted into polygons, and dissolved into three respective feature classes. The intersect tool was used to join the flood layers with both neighborhood boundaries and census tract boundaries. Within the resulting six shapefiles, two new fields were added in each to calculate the area of flooding within each neighborhood boundary or census tract boundary and the percent flooded.

Limitations:
Though static flood layers are useful to understand flood risk, they do not allow you to track any progress toward resilience over time. In order to track progress over time and improve reporting, the Planning Department could consider adding a field in Permit & Project Tracking System (PPTS). Additional fields could include inputs from projects' Sea Level Rise Checklists, square footage of buildings upgraded against flood risk, or number of buildings and/or assets upgraded or protected against flood risk.

GOAL 5: ZERO WASTE

PRIORITIZE RESOURCE CONSERVATION, RESPONSIBILITY & REUSE

TARGET 13: 100% RESPONSIBLE MATERIAL USE

Indicator: Project Responsible Material Use and Reuse
Measure(s): LEED Materials and Resources credits per project
Unit: Number of credits
Data: LEED Project Directory (table) - LEED

Under San Francisco's Construction and Demolition (C&D) Ordinance, all C&D debris material from a project must be recycled or reused by being transported off-site by a Registered Transporter and taken to a Registered Facility.[55] There are hundreds of Registered Transporters and 14 Registered Facilities, located within and nearby the City, making it difficult to track the amount of debris being created, transported, and recycled/ reused. Due to the ordinance, 100% of construction waste is being recycled or reused.

The City does not have specific requirements around recycled, reused, or sustainable materials in new construction, but requires all new residential projects achieve LEED Silver and all commercial projects achieve LEED Gold. LEED-certified projects that receive Materials and Resources credits may re-use or renovate existing structures or use products certified as providing a reduction in environmental impact, raw materials from locations with sustainable extraction practices, or materials that have published reports documenting their safety and health practices throughout the supply chain. LEED is a points-based performance system, making it is useful to evaluate the proportion of credits across categories to understand progress within Materials and Resources.

Methodology:
All non-confidential LEED-certified projects, along with their LEED scorecard values, are stored in the LEED Project Directory. The Directory was filtered for projects located in San Francisco and downloaded. The file was cleaned to fix broken addresses and remove null values (some records did not contain LEED points if they were in the process of being certified). The table of LEED projects was imported into ArcMap and geocoded as point locations using an address locator. Projects are shown on the map with varying symbol sizes based on the number of Materials and Resource credits obtained.

Limitations:
The indicator does not capture projects that are not LEED certified that may still employ sustainable material use (e.g. WELL-certified projects). The LEED Project Directory does not offer a complete inventory of the LEED certified buildings in San Francisco. First, the Directory has not been updated since November 2019 meaning projects that have been certified since then are not included. Second, some records did not include credit information by category even if the building has been recorded as certified. Third, as location data includes hand-typed addresses, some of the projects could not be geocoded, even upon further review.

LEED offers credit for storage and collection of recyclables and C&D waste management. Using the total Materials and Resources score

GOAL 5: ZERO WASTE

PRIORITIZE RESOURCE CONSERVATION, RESPONSIBILITY & REUSE

incorporates C&D waste management, even when it is already required for buildings in San Francisco by the C&D Ordinance. We can make the assumption that projects with higher scores also receive credits for material use and sourcing.

TARGET 14: REFUSE GENERATION REDUCED BY 15%

Indicator: Per-capita waste generation
Measure(s): Refuse generated per capita (landfill, organics, recyclables)
Unit: Pounds/person
Data: Waste generation (table) - SFE/Recology

While most cities focus on diversion rates, reduction in waste generation is a critical gap to be filled. Recology is the sole waste management provider in San Francisco for residential and commercial customers, with the exception of individual customers who may private waste haulers for one-off pickups (e.g. 1-800-JUNK). Due to the current methods of data collection at Recology, neighborhood-level data on waste generation and diversion rates does not exist. Organic and landfill streams are brought to the transfer station at 501 Tunnel Ave, while recycling streams are brought to the Recycle Central/ Pier 96. Upon arrival, waste is weighed and processed, collecting only aggregated generation and diversion data. While this allows for city-wide analysis of waste generation and diversion rates, it poses a challenge for analyzing data at smaller scales, such as at the neighborhood-level.

Methodology:
As a proxy for estimating baseline waste generation, citywide aggregated Recology data for 2018 was acquired from SFE's Zero Waste team. The data includes total tonnage of each stream generated, which was used to calculate each stream's contribution to total waste generation and per capita generation metrics.

Limitations:
Without granular waste generation data, we cannot discern local discrepancies in waste generation. Collecting neighborhood-level waste generation data would require changing Recology's data collection methodology. The Department of Sanitation of New York (DSNY) tracks and reports monthly waste statistics at the community district level. Curbside and containerized collection routes serve individual community districts. The trucks on these routes pass over scales each day which then transmits tonnage data into DSNY's centralized computer system. Given San Francisco's smaller size, this would likely not be possible at the neighborhood-level (which vary dramatically in size), but rather through specific waste collection zones.

GOAL 5: ZERO WASTE

PRIORITIZE RESOURCE CONSERVATION, RESPONSIBILITY & REUSE

TARGET 15: 100% MATERIALS RECOVERED FROM WASTE STREAM

Indicator: Waste recovery
Measure(s): Diversion rates (landfill, organics, recyclables)
Unit: Tons diverted; percent diverted
Data: Waste diversion (table) - SFE/Recology

San Francisco was one of the first cities in the country to create a residential three-stream waste collection program (recyclables, trash, organics). The City passed the Mandatory Composting and Recycling Ordinance in 2009 requiring all buildings to provide recycling and composting service, post appropriate signage, and educate all tenants at least once a year. Though the city has achieved an 80 percent diversion rate overall, this figure is heavily influence by large commercial and industrial operators (who have considerable control over their waste and resource stream) and by the C&D trades, where enormous amounts of materials are recovered due to the City's C&D requirements.

Recology is the sole waste management provider in San Francisco for residential and commercial customers, with the exception of individual customers who may private waste haulers for one-off pickups (e.g. 1-800-JUNK). Due to the current methods of data collection at Recology, neighborhood-level data on waste generation and diversion rates does not exist. Organic and landfill streams are brought to the transfer station at 501 Tunnel Ave while recycling streams are brought to the Recycle Central/Pier 96. Upon arrival, waste is weighed and processed, collecting only aggregated generation and diversion data. While this allows for citywide analysis of waste generation and diversion rates, it poses a challenge for analyzing data at smaller scales, such as at the neighborhood level.

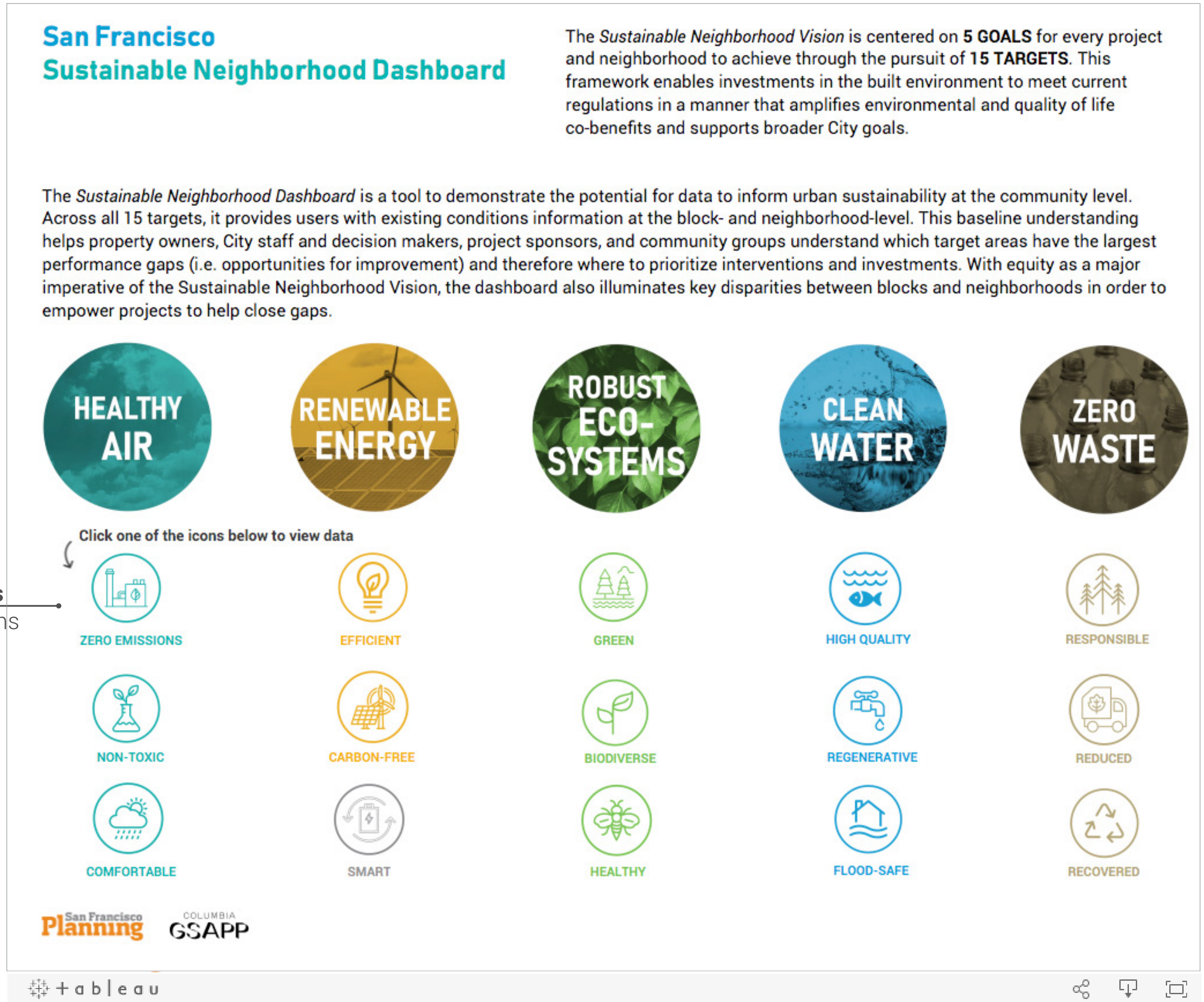
Methodology:
As a proxy for estimating baseline waste diversion, citywide aggregated Recology data for 2018 was acquired from SFE's Zero Waste team. The data included total tonnage of each stream generated and diverted, which was used to calculate diversion rates for each stream and per capita diversion metrics.

Limitations:
Without granular waste diversion data, we cannot discern local discrepancies in waste diversion. Collecting neighborhood-level waste diversion data would require changing Recology's data collection methodology. The Department of Sanitation of New York (DSNY) tracks and reports monthly waste statistics at the community district level. Curbside and containerized collection routes serve individual community districts. The trucks on these routes pass over scales each day which then transmits tonnage data into DSNY's centralized computer system. Given San Francisco's smaller size, this would likely not be possible at the neighborhood-level (which vary dramatically in size), but rather through specific waste collection zones.

PART III

DASHBOARD USER GUIDE

HOME PAGE

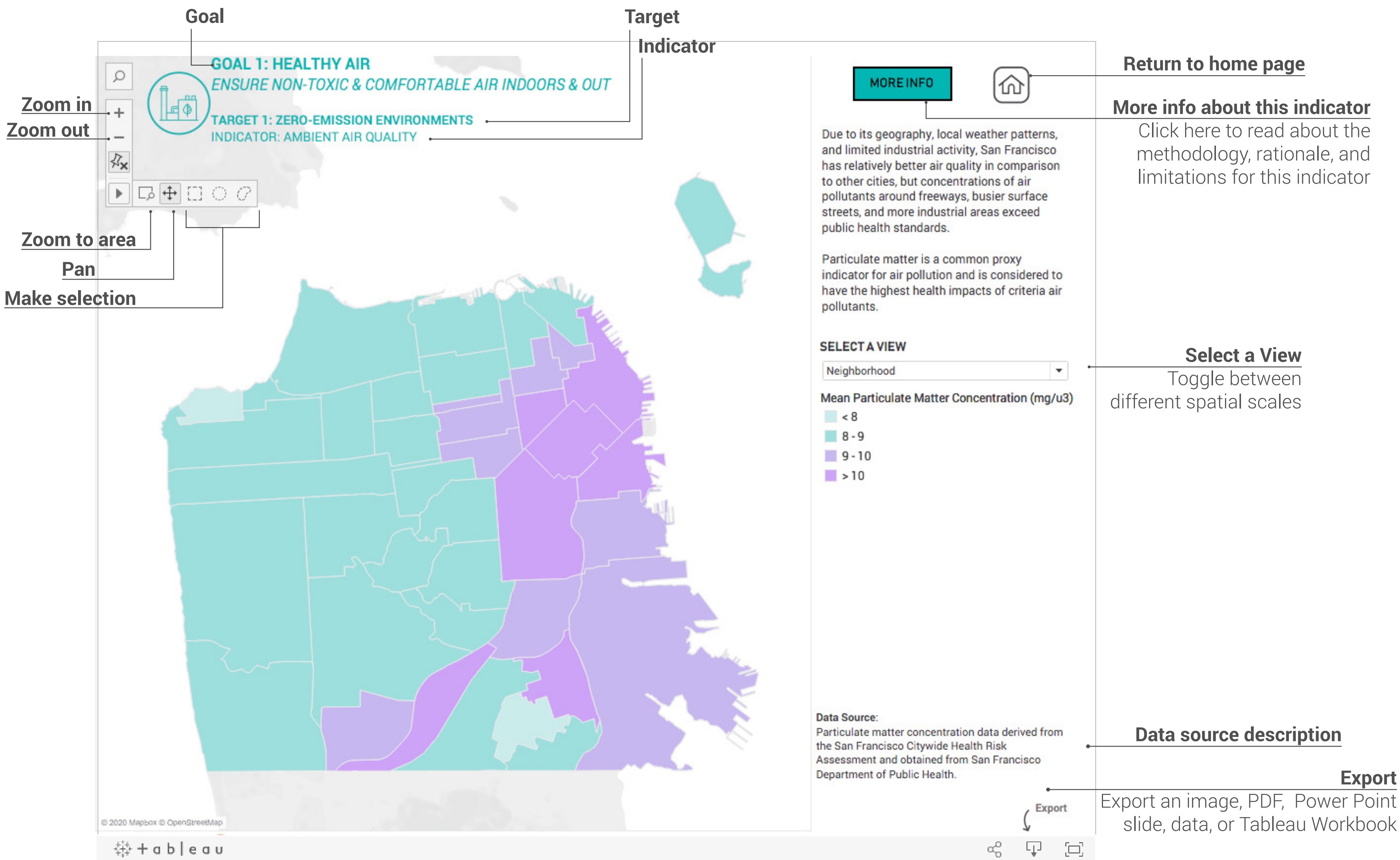


Link to indicator maps
Click one of the 15 icons to navigate to each indicator page where you can view data

5 Sustainable Neighborhood Framework Goals

15 Sustainable Neighborhood Framework Targets

INDICATOR MAP PAGE



INDICATOR INFO PAGE

Goal

Target

Indicator

Return to home page

Return to indicator map page

GOAL 1: HEALTHY AIR

ENSURE NON-TOXIC & COMFORTABLE AIR INDOORS & OUT

TARGET 1: ZERO-EMISSION ENVIRONMENTS

INDICATOR: AMBIENT AIR QUALITY

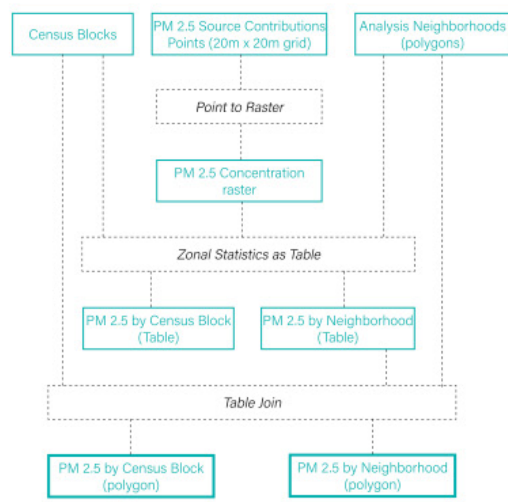
BACK TO MAP

Methodology
Read a description about how this indicator was prepared and analyzed

Methodology:
Particulate matter estimates were derived from the San Francisco Citywide Health Risk Assessment (Citywide HRA) analysis developed in 2020. The Citywide HRA evaluated source contributions at point locations on a receptor grid of 20 meters by 20 meters. Concentration of a pollutant at each receptor point location was calculated by multiplying the estimated annual average emissions of the pollutant by the dispersion factor for the source. The Planning Department's Environmental Planning division shared the estimated PM2.5 concentration grid.

The grid was converted from point features to a raster dataset using the Point to Raster tool from the ArcGIS Conversion toolbox. In doing so, the total PM 2.5 concentration (sum of traffic, stationary, railway, maritime, and background emissions) value for each point was assigned to the output raster cells. The resulting raster layer shows the annual average PM 2.5 from all modeled sources and background concentrations throughout San Francisco in 2020.

PM 2.5 concentrations values for each neighborhood boundary and census tract were calculated using the Zonal Statistics as Table tool from the ArcGIS Spatial Analyst Toolbox, which summarizes the raster cells within designated zones (i.e. neighborhood boundaries and census tracts). The resulting summary statistics tables were appended to the neighborhood and census tract boundary polygons using a table join.



Technical diagram
This chart shows the technical analysis methods used to analyze this indicator

Limitations
Read about the limitations of using this particular indicator and dataset

Limitations:
Displaying the mean PM 2.5 concentration for each neighborhood does not take into account the differences with the neighborhood. When aggregating to a larger geography, the data becomes coarser. Evaluating PM 2.5 concentration by neighborhood may be used as a stop-light measure to analyze overall neighborhood trends and trajectories, however, more granular data should be used to evaluate differences within the neighborhood boundary.

Some emissions sources are not included in the HRA analysis because they are either too difficult to analyze, were judged to be less important, or are temporary or intermittent sources. These include: residential wood burning from fireplaces and wood stoves; commercial and residential cooking; indirect sources that generate vehicle trips such as distribution centers, retail centers, and postal service stations; and construction emissions.[i] There are also some uncertainties associated with the estimation of emissions used in the analysis. For example, daily variations in traffic volumes are not captured through the modeling. Though air pollution dispersion modeling is considered to be one of the most effective methods for measuring air pollution exposure (compared to proximity analysis), it does provide some sources of uncertainty. Dispersion modeling does not account for dispersion effects associated with urban heat island effect which leads to longer periods of mixing and generally lower predicted air concentrations.

Data Source:
Particulate matter concentration data derived from the San Francisco Citywide Health Risk Assessment and obtained from San Francisco Department of Public Health.

Data source description

+ a b l e a u

PART IV

RECOMMENDATIONS

This section provides recommendations for specific targets/indicators and opportunities for further research, analysis and dashboard development.

FUTURE DASHBOARD ITERATIONS

TARGETS/INDICATORS

FUTURE DASHBOARD ITERATIONS

SUSTAINABLE NEIGHBORHOOD USE CASES

San Francisco Planning, in collaboration with other agencies, could develop use cases for how the data can inform decision-making for each of the 15 targets. Uses cases may build upon the Sustainable Neighborhood Roadmap (project worksheets) to provide data-driven strategies for reaching goals and targets. For example, at a project level, a certain threshold of ambient air quality (PM 2.5 concentration) could help a project owner determine what type of building ventilation system to install. On the neighborhood level, high percentages of impervious surfaces and higher temporary flooding risk could be used to mobilize community leaders to implement bioswales and raingardens.

SUSTAINABILITY SCENARIO TESTING

Future iterations of the Dashboard could give users the ability to use data to test different sustainability interventions. This would likely need to be at the community-level rather than at the project-level, unless more granular data becomes available. For example, testing could measure the impact of increased tree canopy coverage on urban heat island exposure or evaluate the impact of multi-family energy efficiency interventions on neighborhood-level energy usage. This would make it easier to identify which interventions lead to success and to understand the impacts of different strategies.

AUTOMATIC DASHBOARD UPDATES

Often, city dashboards or urban data projects are taken offline once it is realized that regular updates are not feasible. A dashboard that updates automatically, in real-time or in specified increments of time. Because many of the data sources used come from different agencies, this would be best facilitated by either linking all data sources to the DataSF APIs (which agencies are committed to updating regularly) or creating a shared cross-agency server for data sources. Not all the data sources used, however, were available through DataSF.

TARGETS/INDICATORS

COMFORTABLE

One of the primary limitations with existing UHI analyses is the lack of robust air temperature data. Though air temperature can be estimated for different locations using spatial interpolation, this requires data from several air temperature monitoring stations, of which many cities only have one. In the lack of air temperature data, land surface temperature is often used as a proxy, which does not capture the actual perceived temperature. Partnerships with innovative urban technology companies could be established to deploy sensors and collect data.

For example, Boston, Cambridge, and Brookline launched a partnership with the Museum of Science, Boston, in 2019 to study the impact of extreme heat and urban heat island effect through citizen science.[56] The project provided the cities with high resolution air temperature data, giving a better representation of exposure to heat. The project divided the three cities into ten mapping routes. Citizen science teams were made up of at least one driver and one navigator, who drove around for hour-long mapping periods to record temperature and geospatial data. Traverses were conducted by mounting sensor equipment on a car and driving designated routes at 6 a.m., 3 p.m., and 7 p.m. on a hot, clear day. The sensors tracked GPS location, temperature, and humidity at one second intervals. The data was analyzed by CAPA Strategies using a machine learning algorithm that incorporates local data and satellite imagery to show heat distribution for the three cities.

MAXIMUM ENERGY EFFICIENT

Publicly accessible, granular energy usage data would be the most useful to track progress in meeting sustainability targets, develop actionable policies and programs, and educate and empower the public. While energy data privacy regulations are important, they make neighborhood- and project-scale analysis very difficult. Greater collaboration between PG&E, SFPUC, and other city agencies should be pursued to find opportunities to synergize and use available data for common goals.

Energy benchmarking data may also be used for more in-depth analysis. Currently, benchmarking data is used by SFE to track aggregated trends over time. Benchmarking data could be used at a more granular scale to predict energy use intensity for all buildings using regression or machine learning algorithms, which would provide city-wide building-scale data and could be helpful for planning purposes.[57] Benchmarking data could also be used in more in-depth research studies aimed to determine variables contributing to higher energy use intensity.[58, 59]

100% CARBON-FREE ENERGY

Though the California Distributed Generation Statistics maintains a database of all interconnected solar PV systems, there could be more coordination on the local level to track renewable energy progress. SFPUC only has visibility over solar systems that applied to the GoSolarSF program and those installed by SFPUC on municipal properties, while SFE uses aggregated city-wide data.

Electrical permit data could be streamlined using a coding or tagging system to input category (e.g. solar panel, battery energy storage, etc.) and system size, which could then be carried over to the Permit & Project Tracking System (“PPTS”) system.

REGENERATIVE SYSTEMS

Water usage reporting could be improved through amending Existing Buildings Energy Performance Ordinance (Energy Code Chapter 20) to include a water usage benchmarking requirement. New York, Los Angeles, Boston, and Cambridge require water reporting and disclosure along with energy. Improved reporting brings the opportunity for more robust data analysis and visualization, as was done with the NYC Energy & Water Performance Map created in collaboration with the New York University Urban Intelligence Lab.[60] Water use reporting would also create a new dataset that allows for additional analysis, such as prediction of water use intensity for all buildings using regression or machine learning algorithms.[61]

FLOOD SAFE

Though static flood layers are useful to understand risk, they are not useful to track progress over time. In order to track progress and improve reporting, the Planning Department could consider adding a field to PPTS. Additional fields could include inputs from projects’ Sea Level Rise Checklists, square footage of buildings upgraded against flood risk, or number of buildings and/or assets upgraded or protected against flood risk.

WASTE REDUCED/RECOVERED

Though San Francisco is one of the leading cities in the country with respect to waste, granular data is unavailable, making it difficult to apply evidence-driven community interventions. SFE and Recology may want to explore innovative approaches to accessing localized data that can better inform their waste programs and educational efforts. Collecting neighborhood-level waste generation and diversion data need not require an entire re-configuration of Recology's routes. The Department of Sanitation of New York (DSNY) tracks and reports monthly waste statistics at the community district level by passing their trucks over scales each day which then transmits tonnage data into DSNY's centralized computer system. Given San Francisco's smaller size, this would likely not be possible at the neighborhood-level (which vary dramatically in size), but rather through specific waste collection zones.

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APPENDIX

APPENDIX A SUSTAINABILITY METRICS SCAN

SUSTAINABILITY INDICATOR METRIC SCAN

This spreadsheet identifies key sustainability performance metrics used by other cities, as well as aligning targets.

**Some performance metrics are not paired with a target.*

City	Vancouver		Portland		New York		Los Angeles		Seattle	
Plan/Program	Greenest City 2020 Action Plan		Portland Plan (2011) and 2015 Climate Action Plan		OneNYC (2015)		Sustainable City Plan		Seattle 2035 Comprehensive Plan	
Sub-Categories	**Performance Metrics**	**Targets**	**Performance Metrics**	**Targets**	**Performance Metrics**	**Targets**	**Performance Metrics**	**Targets**	**Performance Metrics**	**Targets**
HEALTHY AIR	Total number of instances not meeting of air quality standards	Always meet or beat the most stringent air quality guidelines from Metro Vancouver, British Columbia, Canada, and the World Health Organization	Percent of Portlanders that walk, bike, take transit or carpool to work or work from home	Create vibrant neighborhoods where 80 percent of residents can easily walk or bicycle to meet all basic daily, non-work needs and have safe pedestrian or bicycle access to transit. Reduce daily per capita vehicle miles traveled by 30 percent from 2008 levels	Greenhouse gas emissions reductions relative to 2005	80% reduction by 2050 relative to 2005	Annual childhood asthma-related emergency room visits	Reduce the number of annual childhood asthma-related emergency room visits in L.A.'s most contaminated neighborhoods to less than 14 per 1,000 children by 2025; and 8 per 1,000 children by 2035	Passenger vehicle emissions (million tonnes CO_2e)	82% reduction
	Per cent mode share by walk, bike and transit	Make the majority (over 50%) of trips by foot, bicycle, and public transit		Improve the efficiency of freight movement within and through the Portland metropolitan area	Air-quality ranking among major U.S. cities	New York City will have the best air quality among all large U.S. cities by 2030	Percent of all trips made by non-car modes	Increase the percentage of all trips made by walking, biking, micro-mobility/matched rides or transit to at least 35% by 2025; 50% by 2035; and maintain at least 50% by 2050	Vehicle Miles Traveled (VMTs)	20% reduction by 2030
	Total vehicle km driven per person	Reduce the average distance driven per resident by 20% from 2007 levels		Improve the fuel efficiency of passenger vehicles to 40 miles per gallon and manage the road system to minimize emissions.	Disparity in SO_2 across city neighborhoods	50% reduction (2.25 ppb) by 2030	VMT per capita per day	Reduce VMT per capita by at least 13% by 2025; 39% by 2035; and 45% by 2050	GHG emissions intensity of travel (GHG emissions per mile of Seattle vehicles)	75% reduction by 2030
	Total tonnes of community CO_2e emissions from Vancouver	Reduce community-based greenhouse gas emissions by 33% from 2007 levels.		Reduce lifecycle carbon emissions of transportation fuels by 20 percent	Disparity in PM2.5 levels across city neighborhoods	20% reduction (5.32 mg/m3) by 2030		Ensure Los Angeles is prepared for Autonomous Vehicles (AV) by the 2028 Olympic and Paralympic Games	Mode share (center city commute trips and all trips)	Trend away from single occupant vehicles
			Carbon emissions	Reduce carbon emissions by 40% from 1990 levels by 2030 and by 80% reduction from 1990 levles by 2050			Percentage of electric and zero emission vehicles (CA Department of Motor Vehicles)	Increase the percentage of electric and zero emission vehicles in the city to 25% by 2025; 80% by 2035; and 100% by 2050	Transit ridership	Increase in transit mode share and ridership
				Reduce risks and impacts from heat, drought, and wildfire by preparing for hotter, drier summers with increased incidence of extreme heat days.			Percent of LA Metro and LADOT electrified	Electrify 100% of LA Metro and LADOT buses by 2030	Transit service	Increase in transit service hours and service levels
								Reduce port-related GHG emissions by 80% by 2050	Bike ridership	Triple amount of biking from 2007 levels by 2017
							Number of exceedance days	Reach the US EPA 80 ppb ozone attainment standard by 2025 and meet all future compliance dates		
							Million metric tons CO_2e	Reduce industrial emissions by 38% by 2035; and 82% by 2050		
							Million metric tons CO_2e	Reduce methane leak emissions by 54% by 2035; and 80% by 2050		
							Annual-mean daytime temperature	Reduce urban/rural temperature differential by at least 1.7 degrees by 2025; and 3 degrees by 2035		
RENEWABLE ENERGY	Total tonnes of CO_2e from all community buildings	Reduce energy use and GHG emissions in existing buildings by 20% from 2007 levels		Reduce the total energy use of all building built before 2010 by 25%			Local solar capacity	Increase local solar capacity to 900-1,500 MW (2025); 1,500-1,800 MW (2035); and 1,950 MW (2050)	Commercial building emissions (million tonnes CO_2e)	45% reduction by 2030
	Kilograms of CO_2e per square metre of newly built floor area	Require all buildings constructed from 2020 onward to be carbon neutral in operations		Achieve zero net carbon emissions in all new buildings and homes			Local energy storage capacity	Increase energy storage capacity to 1,654-1,750 MW (2025); 3,000 MW (2035); and 4,000 MW (2050)	Commercial building energy use (trillion BTU)	10% reduction by 2030
			Percent of energy from renewable sources	Supply 50% of all energy used in buildings from renewable resources, wih 10% produced within the county from on-site renewable sources, such as solar.			Demand response programs capacity	Increase demand response programs to 234 MW (2025) and 600 MW (2035)	Residential building emissions (million tonnes CO_2e)	32% reduction by 2030
							Percentage of L.A. energy supplied with renewable energy sources	55% renewable energy by 2025; 80% renewable energy by 2036; and 100% renewable energy by 2045	Residential energy use (trillion BTU)	20% reduction by 2030
							Percentage of net zero carbon buildings	All new buildings will be net zero carbon by 2030; and 100% of buildings will be net zero carbon by 2050	Commercial and residential (combined) building energy emissions (million tonnes CO_2e)	39% reduction by 2030
							Building energy use per sq. ft. (mBTU/sqft)	Reduce building energy use per sq. ft. for all building types 22% by 2025; 34% by 2035; and 44% by 2050	Commercial and residential (combined) energy use (emissions/BTU)	25% reduction by 2030
									Multifamily residential and commercial buildings energy use intensity (EUI) of existing buildings	Decrease in average EUI, develop EUI target by 2020

SUSTAINABILITY INDICATOR METRIC SCAN

This spreadsheet identifies key sustainability performance metrics used by other cities, as well as aligning targets.

**Some performance metrics are not paired with a target.*

City	Vancouver		Portland		New York		Los Angeles		Seattle	
Plan/Program	Greenest City 2020 Action Plan		Portland Plan (2011) and 2015 Climate Action Plan		OneNYC (2015)		Sustainable City Plan		Seattle 2035 Comprehensive Plan	
Sub-Categories	Performance Metrics	Targets	Performance Metrics	Targets	Performance Metrics	Targets	Performance Metrics	Targets	Performance Metrics	Targets
ROBUST ECOSYTEMS	% of city's land base within a 5 min walk to green space	All Vancouver residents live within a five-minute walk of a park, greenway, or other green space by 2020		Reduce the consumption of carbon-intensive foods and support a community-based food system	Percentage of New Yorkers living within a walking distance of a park	85% by 2030	Number of residents	Ensure all low-income live within 1/2 mile of fresh food by 2035	Open space provision	Increase number of Urban Villages meeting open space goals
	Total number of additional trees planted	Plant 150,000 new trees by 2020	Percent of impervious areas	Reduce effective impervious areas by 600 acres			Number of urban agriculture sites	Increase the number of urban agriculture sites in L.A. by at least 25% by 2025; and 50% by 2035		
	Total number of neighborhood food assets	Increase city-wide and neighbourhood food assets by a minimum of 50% over 2010 levels	Forest canopy coverage	Expand the urban forest canopy to cover at least one-third of the city, with a minimum canopy cover of 25 percent of each residential neighborhood and 15 percent of the central city, commercial and industrial areas				Prepare for natural disasters by increasing the resiliency of our food systems infrastructure		
	Total hectares of natural areas restored or enhanced	Restore or enhance 25 hectares of natural areas between 2010 and 2020.					Tree canopy coverage	Increase tree canopy in areas of greatest need by at least 50% by 2028		
	Per cent of city's land area covered by tree-leaf canopies	Increase canopy cover to 22% by 2050.						Achieve and maintain 'no-net loss' of native biodiversity in 2035		
							Miles of Los Angeles River public access	Create a fully connected LARiverWay public access system that include 32 miles of bike paths and trails by 2028		
							Percentage of residents	Ensure proportion living within 1/2 mile of a park or open space is at least 65% by 2025; 75% by 2035; and 100% by 2050		
CLEAN WATER	Total number of instances not meeting of water quality standards	Meet or beat the strongest of British Columbian, Canadian, and appropriate international drinking water quality standards and guidelines.		Reduce risks and impacts from flooding and landslides by preparing for warmer winters with the potential for more intense rain events.	Violations with Safe Drinking Water Act	No SDWA violations	Percentage of L.A. water from local sources	Source 70% of L.A.'s water locally		
	Total water consumption per capita	Reduce per capita water consumption by 33% from 2006 levels	Water Quality Index	By 2035, all of Portland's watersheds have a score of 60 or higher on the Portland Water Quality Index and the Willamette Watershed has a score of at least 75.	Backlog of catch basin repairs	Maintain < 1%	Stormwater captured (acre ft/year	Capture 150,000 acre ft/year of stormwater by 2035		
					Combined Sewer Overflow capture rate	Increase	Percentage of wastewater recycle	Recycle 100% of all wastewater for beneficial reuse by 2035		
					Number of flood insurance policies across the city	Increase	Number of stormwater capture pr	Build at least 10 new multi-benefit stormwater capture projects by 2025; 100 by 2035; and 200 by 2050		
					Square footage of buildings upgraded against flood risk	Increase	Potable water use per capita	Reduce potable water use per capita by 22.5% by 2025; and 25% by 2035; and maintain or reduce 2035 per capita water use through 2050		
					Number of elevated homes in the Build it Back program (cumulative)	Increase	Number of hydration stations	Install or refurbish hydration stations at 200 sites, prioritizing municipally-owned buildings and public properties such as parks by 2035		
					Linear feet of coastal defenses completed	Increase				
					Access of coastal ecosystems restored	Increase				
					Number of residents benefitting from coastal defenses and restored ecosystems	Increase				
ZERO WASTE	Annual tons of solid waste disposed to lanfill or incinerator	Reduce solid waste going to the landfill or incinerator by 50% from 2008 levels	solid waste	Reduce food scraps sent to landfills by 90 percent	Volume of DSNY-collected refuse (excluding material collected for reuse/recycling) relative to 2005 baseline of ~3.6M tons	90% reduction by 2030 from 2005 baseline of 3,588,600 tons	Diversion rate	Increase landfill diversion rate to 90% by 2025; 95% by 2035; and 100% by 2050	Waste diverted from landfill to rec	70% diversion rate by 2022
			solid waste per capita	Reduce per capita solid waste by 33 percent	Curbside and Containerized Diversion Rate	Increase	Pounds of waste generated per ca	Reduce municipal solid waste generation per capita by at least 15% by 2030, including phasing out single-use plastics by 2028	Methane emissions from landfill	50% reduction in methane emissions by 2020
				Reduce consumption-related emissions by encouraging sustainable consumption and supporting Portland business in minimizing the carbon intensity of their supply chains.	Citywide diversion rate (including all streams of waste: residential, commercial, construction and demolition, and fill)	Increase	Tons of organic waste to landfill p	Eliminate organic waste going to landfill by 2028		
				Recover 90 percent of all waste generated				Increase proportion of waste products and recyclables productively reused and/or repurposed within L.A. County to at least 25% by 2025; and 50% by 2035		

SUSTAINABILITY INDICATOR METRIC SCAN

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City / Plan/Program	Chicacgo Sustainable Chicago 2015		Amsterdam Amsterdam Sustainability Program ("Amsterdam: Definitely Sustainable", 2011-2014)		Copenhagen Climate Action Plan		Copenhagen Copenhagen: Solutions for Sustainable Cities:		EcoDistricts		LEED ND	
Sub-Categories	**Performance Metrics**	**Targets**	**Performance Metrics**	**Targets**	**Performance Metrics**	**Targets**	**Performance Metrics**	**Targets**	**Performance Metrics**	**Targets**	**Performance Metrics**	**Targets**
	Daily transit ridership	Increase average daily transit ridership	Materials & Consumers	The GGD's indicators for progress achieved through its 'healthy neighbourhood' strategy.		75% of all trips by foot, bike, or public transit by 2025	Health expenses saved by cycling per year		Annual air quality index score	Air quality is protected from criteria pollutants	Heat island reduction	Green Infrastructure & Buildings
		Accelerate transit-oriented development around transit stations	Materials & Consumers	Quality of the environment based on air quality, noise, external safety and soil quality.		50% of trips to work or school are by bike by 2025	Net social gain for every km travelled by bike instead of car		Vehicle miles or kilometers traveled daily per capita	District traval, internally and externally, is safe, efficient, and multimodal	Construction activity pollution prevention	Green Infrastructure & Buildings
	Mode share	Make Chicago the most bike and pedestrian friendly city in the country	Sustainable Mobility & Air Quality	In 2014, reduction in annual CO_2 emissions produced by traffic per kilometre driven • Indicator: annual CO_2 emissions produced by traffic and transport.		20% more passengers using public transit by 2025	Healthier citizens reduce health care costs at an estimated rate of € 0.77 per km cycled.		Mode split of daily person trips	District traval, internally and externally, is safe, efficient, and multimodal	Access to quality transit	Smart Location & Linkage
		Strengthen the infrastructure to advance vehicle efficiency	Sustainable Mobility & Air Quality	By the end of 2014, total emissions of harmful substances by the municipal fleet of vehicles will have fallen appreciably • Indicator: annual NO_2 and CO_2 emissions produced by the municipal fleet of vehicles.		Public transit is carbon neutral by 2025	Number of people who cycle because it is the fastest or most convinient wat to get around the city	Increase the number of citizens and commuters cycling to work and education from 35% in 2011 to 50% in 2025	Household car ownership rate	District traval, internally and externally, is safe, efficient, and multimodal	Bicycle facilities	Smart Location & Linkage
HEALTHY AIR		Reduce municipal fossil fuel consumption by 10%	Sustainable Mobility & Air Quality	By 2015 the air quality will satisfy the statutory norms for fine particulate matter (PM) and NO_2 • Indicator: the annual report using the monitoring tool devised by the NSL. (Achieving the desired result depends in part on the efforts of regional and national governments.)		20-30% of all light vehicles run on new fuels such as electricity, hydrogen, biogas or bioethanol by 2025	Distance in km travelled eachday in city by bicycle		Number of "first and last mile" options at major transit stops	District traval, internally and externally, is safe, efficient, and multimodal	Walkable streets (required)	Neighborhood Pattern & Design
	Carbon emissions	Reduce carbon emissions from all sectors				30-40% of all heavy vehicles run on new fuels by 2025	Number of car trips	Integrated public transportation	Number of bike and car share stations	Shared mobility options are increased	Compact development (required)	Neighborhood Pattern & Design
		Improve local air quality by accelerating performance towards federal standards and declaring greenhouse gas emissions				20-30% of all light vehicles run on new fuels such as electricity, hydrogen, biogas or bioethanol by 2025			Percentage of population using shared cars and bikes annually	Shared mobility options are increased	Mixed-use neighborhoods	Neighborhood Pattern & Design
		Protect the city and its residents by preparing for changes in the climate				Public transit is carbon neutral by 2025			Number of days annually that air quality emission standards are exceeded in and near the district	Toxic environments are remediated and regenerated	Reduced parking footprint	Neighborhood Pattern & Design
						All city administration vehicles run on electricity, hydrogen, or biofuels			Per capita net tons CO_2 emissions/year		Transit facilities	Neighborhood Pattern & Design
											Tree-lined and shaded streetscapes	Neighborhood Pattern & Design
	Energy use (million kBTUs)	Improve citywide energy efficiency by 5%	Climate and energy:	In 2014 Amsterdam's annual CO_2 emissions will have stabilised • Stabilisation of CO_2 emissions generated by small- and large-scale consumers as well as by kilometres travelled within the municipality. • The degree to which the municipal organisation is climate-neutral, e.g. as a percentage of the whole.		20% reduction in heat consumption by 2025 (compared to 2010)			Average energy use index for new building construction	All sectors improve energy efficiency, reduce waste, and increase natural carbon sinks.	Solar orientation	Green Infrastructure & Buildings
	Energy use (million kBTUs)	Improve overall energy efficiency in municipal buildings by 10%				Energy: 20% reduction in electricity consumption in commercial/service companies by 2025 (compared to 2010)	Electricity production from wind power	Target 100+ new wind turbines by 2025	Percent of annual electricity demand met by district-based renewable power generation	Electricity is decarbonized	Renewable energy production	Green Infrastructure & Buildings
RENEWABLE ENERGY	Percentage of electricity generated by renewable sources	Create an additional 20MW of renewable energy, consistent wit the Illinois RPS				Energy: 10% reduction in electricity consumption in households by 2025 (compared to 2010)			Carbon content of local grid-delivered electricity (CO_2 pounds/MWh)	Electricity is decarbonized	District heating and cooling	Green Infrastructure & Buildings
						Energy: Installation of solar cells corresponding to 1 percent of electricity consumption by 2025			Carbon and carbon-free fuel shares for household vehicle (percent clean Evs)	All sectors shift to renewable power and carbon-free fuels	Infrastructure energy efficiency	Green Infrastructure & Buildings
						Energy: 40% reduction in energy consumption in municipal buildings by 2025			Average residential electricity & natural gas use (million Btu/year)		Optimize building energy performance	Green Infrastructure & Buildings
						District heating in CPH is carbon neutral by 2025			Average household fossil fuel use (gallons/year)		Certified green buildings	Green Infrastructure & Buildings
						Power generation based on wind and biomass, and exceeds CPH requirements, by 2025			Per capita total energy use in million Btu/year			
						Biogasification of organic waste by 2025			Renewable power generated in MWh			
						Energy consumption for street lighting in Copenhagen is halved compared to 2010						

SUSTAINABILITY INDICATOR METRIC SCAN

This spreadsheet identifies key sustainability performance metrics used by other cities, as well as aligning targets.

**Some performance metrics are not paired with a target.*

City	Chicacgo		Amsterdam		Copenhagen		Copenhagen		EcoDistricts		LEED ND	
Plan/Program	**Sustainable Chicago 2015**		**Amsterdam Sustainability Program ("Amsterdam: Definitely Sustainable", 2011-2014)**		**Climate Action Plan**		**Copenhagen: Solutions for Sustainable Cities:**					
Sub-Categories	**Performance Metrics**	**Targets**	**Performance Metrics**	**Targets**	**Performance Metrics**	**Targets**	**Performance Metrics**	**Targets**	**Performance Metrics**	**Targets**	**Performance Metrics**	**Targets**
ROBUST ECOSYTEMS	Acres of parkland	Increase the number of public spaces and parks accessible for Chicagoans							Percent of district with tree canopy	All sectors improve energy efficiency, reduce waste, and increase natural carbon sinks.	Minimized site disturbance	Green Infrastructure & Buildings
	Acres of urban agriculture	Increase options for assessing local or healthy food in every neighborhood							Percentage of residents within a 1 mile walk to natural open space	Access to nature is improved	Restoration of habitat or wetlands and water bodies	Smart Location & Linkage
	Species of migratory birds	Improve and protect Chicago's natural assets and biodiversity							Percentage of dwelling units within a 0.5 mile walk of a fresh food outlet	Healthy and affordable fresh food is accessible	Local food production	Neighborhood Pattern & Design
									Area per capita used for food production	Food production in the district is encouraged	Tree-lined and shaded streetscapes	Neighborhood Pattern & Design
									Percentage of households with a home garden or using a community garden	Food production in the district is encouraged		
									Quantity of local fresh food procured annually by establishments in the district	Food production in the district is encouraged		
CLEAN WATER	Water use (gallons per day)	Decrease water use by 2% (14 million gallons per day) annually					Annual water consumption trends	Reduction in citizen water consumption from 100 litres/day to 90 litres/day in 2025.	Gallons of water used daily per capita, indoors and outdoors	Potable water is used efficiently	Wastewater management	Green Infrastructure & Buildings
	Square feet of impervious surfaces	Enhance stormwater management to reduce sewer overflows and basement flooding							Percent of buildings connected to non-potable water sources	Alternative water sources are used for non-potable purposes	Rainwater management	Green Infrastructure & Buildings
		Protect water quality and enhance access to Lake Michigan							Annual water quality index score	Water quality is protected from pollutants	Indoor water use reduction	Green Infrastructure & Buildings
									Average buffer distance protecting wetlands and water bodies	Natural features are protected	Outdoor water use reduction	Green Infrastructure & Buildings
									Percentage of 50-year storm event managed within district	Rainwater is managed in the district	Restoration of habitat or wetlands and water bodies	Smart Location & Linkage
									Ratio of pervious to impervious surfaces	Rainwater is managed in the district	Floodplain Avoidance	Smart Location & Linkage
									Percentage of land area in 100-year floodplaing			
									Percentage of land area subject to sea level rise			
ZERO WASTE	Tons of waste, percentage recycled, percentage from C&D	Increase access to recycling and improve policies to promote waste reduction and re-use	Materials & Consumers	The increase in the volume of sorted, recyclable domestic waste (glass, paper, plastic) that is collected and the associated reduction in the volume of non-recyclable refuse from households and businesses that is delivered to the AEB's waste and energy plant for incineration (based on annual reports by the SRGA municipal sanitation service and the AEB).	Waste	Separation of plastic - domestic and commercial by 2025	Tons of waste sent to landfill	reduce the amount of waste sent to landfill and instread increase the waste that is recycled and used to generate heat for the city's heating network	Percentage of non-hazardous waste divered from landfills annually	Waste is diverted from landfills through reduction, reuse, and recycling	Recycled and reused infrastructure	Green Infrastructure & Buildings
		Incorporate standard green practices in all city operations	Materials & Consumers	Percentage of annual expenditure by municipal departments, services and city boroughs that is being procured sustainably					Percentage of organic waste diverted from energy recovery or composting annually	The residual value of organic waste is captured	Solid waste management	Green Infrastructure & Buildings
											Historic resource preservation and adaptive reuse	Green Infrastructure & Buildings
											Building reuse	Green Infrastructure & Buildings