Neighbourhood level cooling

Experiences from C40's Cool Cities Network

April 2021

C40 CITIES

Introduction

As rising urban temperatures and heat waves increasingly grip cities, local neighbourhoods are often impacted differently. The urban heat island effect as well as social vulnerabilities often differ across urban areas. Each neighbourhood has its own urban form, local characteristics, and community needs. Cooling solutions therefore need to be adapted to local contexts.

This report showcases examples of nine member cities of C40's Cool Cities Network on how to understand the local level to monitor the urban heat island effect, involve the local communities and implement cooling solutions.

Table of content

City recommendations

Analysing the urban micro-climate at the local level

Melbourne
Establish a **multi-disciplinary team** to deliver local projects. A data analytics and sensor/IoT project requires a combination of skills to create valuable insights from the data, for example selecting sensors, install, test, ingest data, structure data, analyse and visualise data.

Buenos Aires
It is necessary to address the characterisation of heat and urban heat island in the areas of **informal settlements** since they represent one of the populations with the greatest vulnerability.

Lisbon
The **quality of the output data** should be guaranteed as possible: it should be carefully verified before launching out to the public.

Tel Aviv
Precise mapping of urban trees can become extremely useful not only for shade mapping, but also for understanding the efficacy in tree planting for climatic purposes.

Involving the local community to identify cooling needs & solutions

Philadelphia
Center **community empowerment** when planning/implementing heat resiliency measures; hearing from community members on the topic is the crucial first step to planning AND implementation

Quito
The development of a **co-benefits analysis** of the action is essential in order to highlight the potential of the action and to get the support from the citizens and from other institutions that might fund the action.

Implementing local-level cooling interventions

Milan
Trying a **new solution with a pilot** is a first step to demonstrate that a new today can become a new everyday.

Los Angeles
Selecting neighbourhoods by mapping multiple data sets including heat islands, underserved communities, and transit-dependent households

Austin
Start early and integrate (district cooling) system into planned infrastructure

1. Analysing The Urban Micro-Climate At The Local Level

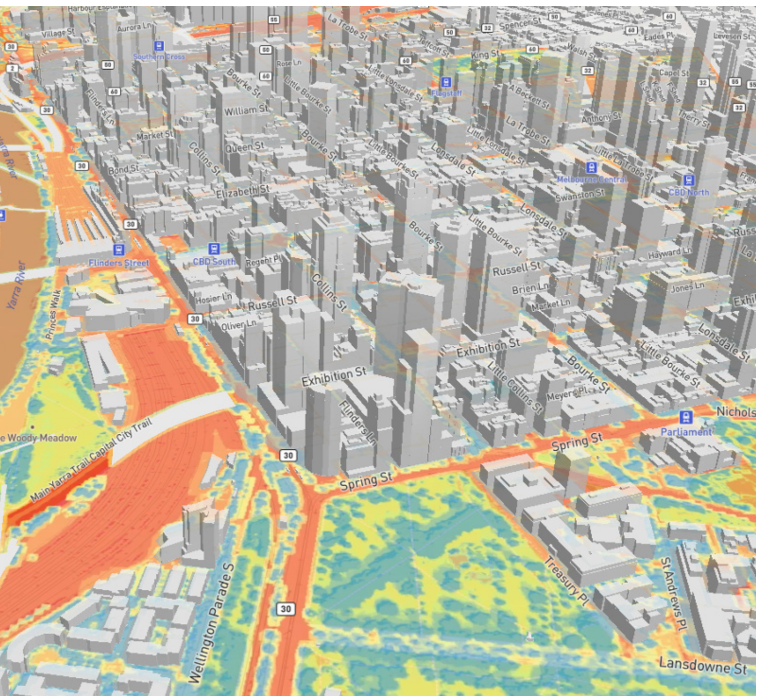
Melbourne

Identifying priority locations for cooling interventions through the analysis of micro-climate data

Overview of the Project

For the 'Cooling the City' project, the Municipality and research & innovation partners installed six **microclimate sensors** in the Melbourne Innovation District in 2019, with the aim to measure the success of investments, choose the right materials for different streetscapes and verify the city's Cool Routes thermal comfort model.

The six sites chosen represented **various streetscapes** – from exposed asphalt, poor to good canopy cover and a shade structure in the form of an awning. The multidisciplinary team that was formed to deliver this pilot created a data visualisation tool so the Climate Change Action team could easily translate the data.
Melbourne neighbourhoods have different built form and density, road types and amount of open green space, all of which can impact microclimate. By capturing localised microclimate data we can understand what specific cooling interventions such as tree canopy, shading or light coloured paving are most effective and appropriate for the different neighbourhoods across Melbourne.



Key learnings

1. Effectiveness of cooling interventions

• Assumptions were made that awnings were an effective intervention due to the shade they create. However, the data has proven that they do not have the same impact on ambient temperature as trees and it has also revealed temperature declines at a slower rate in the evening under these structures. We plan to interrogate this learning further in the next stages of the project to better understand the impact shading structures and radiant heat have on microclimate.

• The data confirmed the literature that trees cool the temp by 2-5 degrees

2. Verification of cool routes as identified in the 'Cool Routes' project

• Sensors were able to validate and confirm assumptions and modelling used to define key routes.

• The sensor data confirms this by tell us air temperature can be between 2-5 degrees cooler under tree canopy than at the exposed asphalt site.

3. How the thermal images captured in 2011 compares to real, on the ground temperatures

• While we are comfortable that the thermal image provides accurate data, the limitation is that it's a snapshot in time. The real time data the sensors provide captures the variation in the temperatures across the day and allows key learnings such as effectiveness of the awnings.

Useful links:

• Cool Routes tool

• Microclimate sensor readings

• Open Data Platform

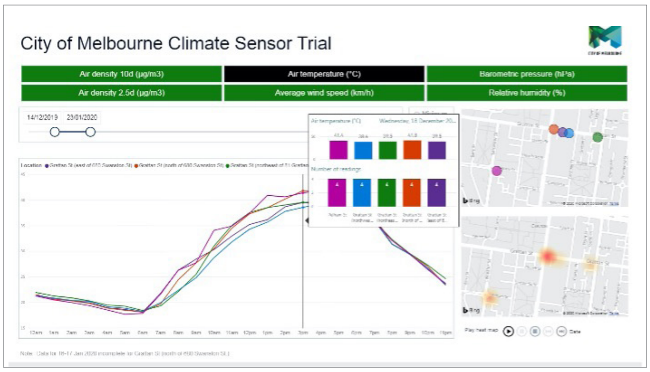
1. Analysing The Urban Micro-Climate At The Local Level

Melbourne - continued
Identifying priority locations for cooling interventions through the analysis of micro-climate data

Challenges faced

Data feed:
• Some challenges occurred with receiving the data in the format that we wanted and in a way that imposed no cost on the organisation. Through this project we learnt that all sensor/device projects should include the raw data to be provided through an API (application programming interface) data feed at no cost to CoM. A standards document has been developed to aid future sensor projects.

Data accuracy:
• Ensuring data accuracy can be challenging. Based on what we learnt through working with the sensor provider we determined that each data attribute measured by a sensor/device requires a specific statement of accuracy (including any calibration requirements).



Recommendations for other cities

Establish a **multi-disciplinary team** to deliver data analytics and sensor/IoT projects. An IoT project requires a combination of skills to create valuable insights from the data, for example selecting sensors, install, test, ingest data, structure data, analyse and visualise data. This project was a collaboration between the data end user (Climate Change Adaptation team), the internal solution provider (Emerging Technology team) and supported by GIS and City Research team.

• Creating a way to **visualise the data** is a great way to communicate findings and show what the data means. We used Power BI to create a dashboard which has provided an impactful way of seeing and translating the data. It has enabled us to easily compare the different sensor sites to understand how temperature and thermal comfort is impacted by cooling interventions.

• Develop a **data dictionary** - This helps us describe the contents, format, and structure of a database and the relationship between its elements. As a result of this project all sensor/device Vendor's must provide a data dictionary, including what measurements are taken, how often the measurements are taken and how often the data is communicated back to the database platform.

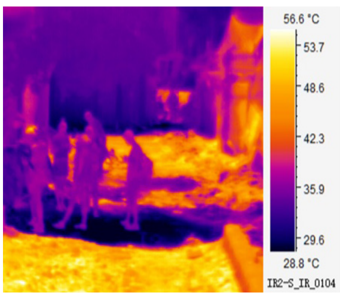
1. Analysing The Urban Micro-Climate At The Local Level

Buenos Aires
Characterisation of urban micro-climates of ‘Barrio 20’

Overview of the Project

The objective of our project was to **characterize the urban microclimates and the influence of urban green infrastructure** (UGI) in Barrio 20, during a day with a high temperature record. Barrio 20 is an **informal settlement** located in Comuna 8 of the Autonomous City of Buenos Aires. One of the main threats for the City is heat waves, which are also often exacerbated due to urban heat island (UHI) effect. This extreme event, together with **existent vulnerable socio economic conditions** in the informal settlements, increases risk and vulnerability for the citizens.

The measurements were carried out on a summer day (February 13, 2020) in representative locations (11) of the neighbourhood exposed to the sun and under shade provided by trees (if present) or provided by structures / buildings. Both air and surface (ground) measurements were made in the time range from 11.00 am to 1.30 pm. The project did not have an assigned budget and due to limited instruments and human resources, measurements were not performed simultaneously at all points. To measure air temperature, a **Davis meteorological station** (model Weather Wizard III) was used, and to measure the ground temperature two **Infrared Thermometer Pyrometer** were used. Measurements were complemented with **photographs taken by a thermographic camera**. All measuring tools were portable.



Key learnings

• Barrio 20 has **different microclimates due to its urban configuration** (characteristics), and lack of green spaces and trees. There are areas with high exposure to the sun (open areas) and internal corridors with lower temperatures.

• The **urbanization process** of informal settlements must include the incorporation of **green infrastructure**.

Challenges faced

• It would be necessary to **strengthen the methodology** to replicate the study more precisely (consider: more measurement instruments and human resources available to carry out more temperature measurements).

• Currently there are no plans to replicate the study in other informal settlements mainly due to the pandemic.

Recommendations for other cities

• It is **necessary to address the characterisation of heat and urban heat island in the areas of informal settlements** since they represent one of the populations with the greatest vulnerability.

• This type of studies will **allow the development of localized strategies** and, possibly, guide cooling policies (tree planting plans, new green spaces, others).

1. Analysing The Urban Micro-Climate At The Local Level

Lisbon

Local sensors network to map urban heat islands

Overview of the Project

Lisbon is launching a sensor network which will deliver **real-time data** for a city-wide picture of climate, but also of air quality, noise and traffic.
The information given by **80 locations** will complement the existing monitoring stations and will enable to study in more detail the spatial variation of meteorological variables (e.g. Temperature, Relative humidity, Wind, Precipitation) and specially the urban heat islands within the city.

The output data will provide analytics for the city as well as third parties, being available through different levels: **open data and internal management platforms**, which disclose raw data, indicators or comprehensive dashboards.

Key learnings

• The **implementation of an extended sensor network should be phased**, beginning with a small pilot area, to test in advance the quality of data; Later on, the municipality will be already prepared to enlarge the net to the whole city.

• In terms of electricity supply, the sensors should be **function on a stand-alone basis, powered by solar energy**.

Useful links:
• Sensor network • Dashboard CML / open data

Challenges faced

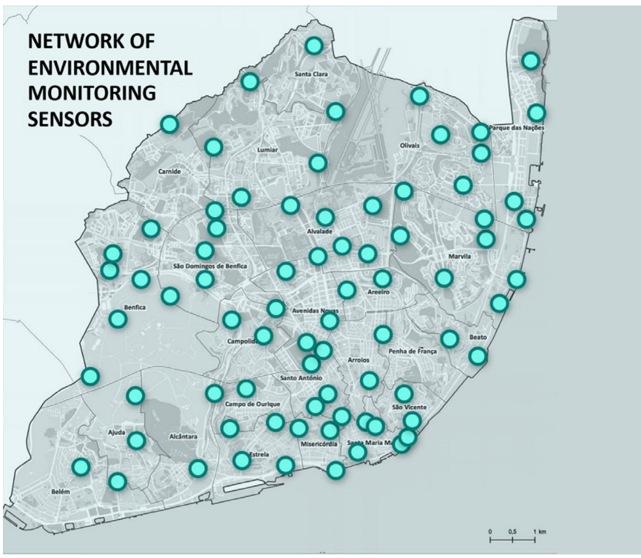
• Difficulties in **finding well distributed locations and spatially spread** all over the city (different parameters – climate, air quality, noise - require specific conditions)

• Constrains during **sensors deployment in the field**, both in public areas (many services operating) and in private areas (land ownership)

Recommendations for other cities

• The **procurement procedures** for the sensor network should include a sensing as a service, as a whole package, instead of acquiring separated goods and services (equipment + communications + operating services…)

• The **quality of the output data should be guaranteed as possible**: it should be carefully verified before launching out to the public (there are always errors and missing data and this kind of monitoring equipment is not officially recognized by the national meteorology authority)



1. Analysing The Urban Micro-Climate At The Local Level

Tel Aviv
Using street- and neighbourhood-level shade maps for prioritising urban action on climate

Overview of the Project

The project's objective was the development of a **quantitative and evidence-based** method for directing urban cooling actions to locations where they are needed the most, focusing on **outdoor shade provision**.

By **applying multi-layered processing and analysis** of existing mapping data of the city, we were able to suggest new, shade-related indicators and benchmarks that could be used for **comparing physical, microclimatic and pedestrian-related properties of streets and neighborhoods** across the city.

The main indicator that was used for analysis was a **summer Shade Index**, calculated for all street segments and neighborhoods alike based on computer-generated values of ground-level solar insolation values.

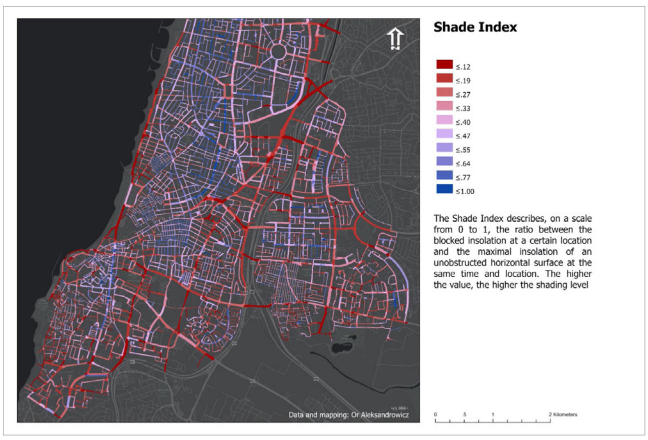
Key learnings

- **Quantitative analysis and mapping of the city's hierarchy of "shade assets"** (the shading of public space by buildings, trees, colonnades, pergolas, or any other device) can become a **useful tool** for climatic urban planning and design.

- By combining Shade Index and pedestrian attraction potential values for each street segment in the city, it was possible to **highlight several central streets that should be prioritized** for shade intensification or shade conservation.

- While shade-related quantitative indicators such as **Tree Canopy Cover or Sky View Factor** are easier to calculate even on a city-level analysis, they **misrepresent the daily and annual variance in solar insolation levels** and thus may lead to wrong conclusions.

- For the sake of resource efficiency, **trees should be regarded as "second-tier" shade providers, on top of street shade provided by buildings**. Thus, denser urban configurations supplemented by tree planting may be a better approach to urban design than more open configurations, which require much more trees for providing similar levels of street shade.



1. Analysing The Urban Micro-Climate At The Local Level

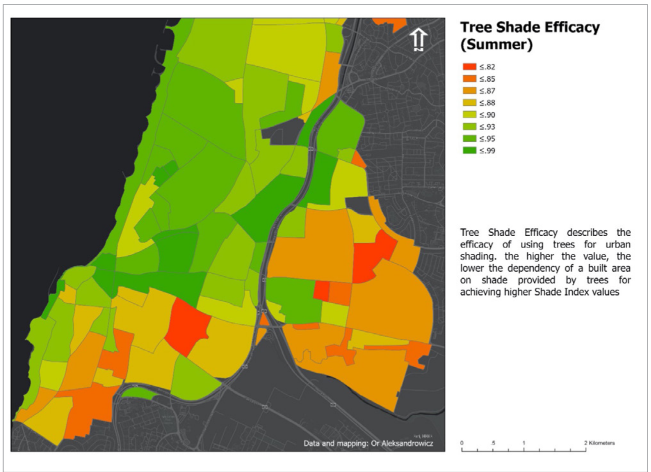
Tel Aviv - continued

Using street- and neighbourhood-level shade maps for prioritising urban action on climate

Challenges faced

• We were able to receive only 2.5D city-scale mapping of all buildings and tree canopies. This meant that the **calculated Shade Index values may have overestimated the effect of tree shade**, since shade under tree canopies was calculated as maximal during the entire day, irrespective of solar orientation and leaf density.

• Currently, there are **no quantitative regulations on shade provision that could be used for setting benchmarks for street and neighborhood Shade Index**. Although we defined lower and upper Shade Index thresholds that require municipal action based on the distribution of Shade Index values in the entire city dataset, further work should be conducted to better define quantitative recommendations on street shade provision.



Useful links:
• Tel Aviv-Yafo Shade and Canopy Cover Maps

Recommendations for other cities

• For effective city-scale shade analysis, **high resolution 2.5D or 3D mapping of the city should be provided**, preferably with tree canopy mapping.

• **Precise mapping of urban trees can become extremely useful** not only for shade mapping, but also for understanding the efficacy in tree planting for climatic purposes.

• Each of the products of a city-scale shade analysis **should be presented in a format of a GIS layer to enable its smooth integration** into internal decision-making processes.

2. Involving the local community to identify cooling needs and solutions

Philadelphia
In-depth community engagement to understand cooling needs of 'Hunting Park' neighbourhood

Overview of the Project

Hunting Park is a heat vulnerable neighbourhood in North Philadelphia with an active environmental advocacy community. In 2018, the Office of Sustainability teamed up with community organizations and **engaged over 600 residents to develop Philadelphia's first ever neighbourhood heat plan**. Following the 2019 release of the plan, implementation began to create a neighbourhood **Heat Relief Network**. The following year, during the COVID 19 pandemic, the project prioritised at-home cooling and virtual engagement. The ongoing work, informed by the Plan, aims to inform residents about what causes extreme heat and **create short- and longterm solutions powered by local residents**.

Key learnings

• The majority of residents think high heat is an **important issue in their community**.

• Cooling strategies must center **energy burden** (the % of income spent on utilities) and work to **provide energy efficiency measures** as well as utility assistance.

• Heat resiliency requires **block-level solutions to best respond to the unique needs of each community**.

• Trash clean-up and beautification are heat resiliency strategies.

Useful links:
• Neighhouhood heat plan "Beat the Heat Hunting Park"
• Article (2020): "Racism left Hunting Park overheated. Neighbors are making a cooler future"

Challenges faced

• COVID-19 congregation restrictions
- Finding opportunities to advance community cohesion without congregating
- Keeping virtual engagement inclusive and accessible

• As a City office, **being able to support the project without leading it**; the goal of the work is to empower community members to be able to lead the project how it best works for them,

Recommendations for other cities

• Center **community empowerment when planning/implementing heat resiliency measures**; hearing from community members on the topic is the crucial first step to planning AND implementation

• **Prioritize storytelling as data**; compensate community members for their wisdom and time in the form of financial payments and/or cooling resources such as fans and a/c units.

• Consider **including energy equity and access** with heat resiliency measures.

2. Involving the local community to identify cooling needs and solutions

Philadelphia
In-depth community engagement to understand cooling needs of ‘Hunting Park’ neighbourhood

Community engagement strategies:

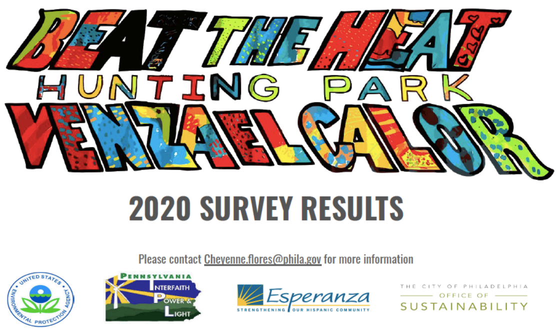
2020

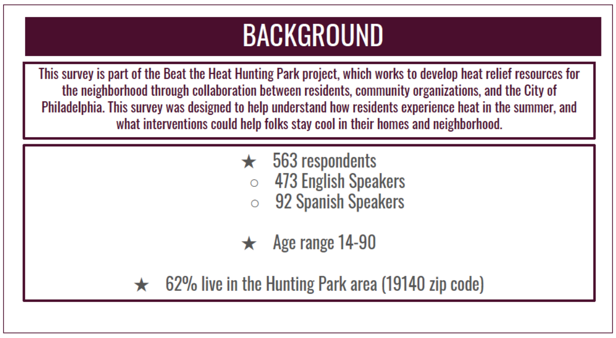
- **Heat Survey** - see example results below
- **Heat Ambassadors** - compensated roles that helped distribute surveys, giveaways, and project info
- **Steering Committee** (Heat Team re-vamped)- helped make decisions meeting weekly in the summer, comprised of majority residents and community orgs with City agency partnerships.
- **Beat the Heat Survey** - a survey to gather information about residents’ priorities around heat and cooling strategies
- **Heat-Relieving Resources Giveaways** - Heat kits with hydration tablets, sunblock, heat safety info, masks and hand sanitizer distributed either at events in the neighborhood including food distribution sites; fans and air conditioning units delivered to residents through our neighbor referral system.
- **Community Cooling Centers** - Through the Steering Committee network, two locations were opened to serve as cooling centers during very hot weather and to distribute surveys and heat health info

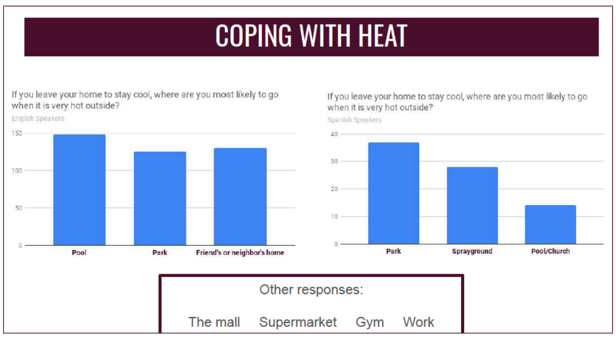
2018

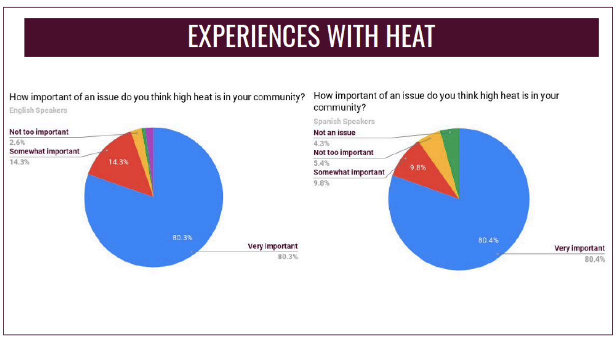
- **Heat Team** - helped make decisions, made up of community orgs, City agencies, and residents
- **Beat the Heat Survey** - a survey to gather information about residents’ priorities around heat and cooling strategies
- **Resource Tables** - held at events in the neighborhood with information about extreme heat and opportunities for residents to give their input on heat planning and take the heat survey.
- **Heat Ambassadors** - compensated roles that helped distribute surveys
- **Heat Design Workshop** - residents identified current and ideal cooling strategies in the neighborhood and neighborhood boundaries

2020 Heat Survey - example results:









2. Involving the local community to identify cooling needs and solutions

Quito

'Clever Cities' - working with local communities to identify nature-based solutions

Overview of the Project

The objective of the Clever Cities project in Quito is the co-creation and co-implementation of nature-based solutions (NBS) in the pilot district of San Enrique de Velasco which is a peri-urban neighbourhood with a high level of environmental degradation. One of the proposed NBS is a tree planting action that could cover over 40% of the area in the main and secondary streets as well as public underused areas in order to reduce the heat island effect along with complementary actions such as the recovery of vegetation cover in ravines, reforestation and the incorporation of NBS criteria in the urban planning of pocket parks and a prototype street that incorporates green infrastructure.

This action is based in a neighbourhood agenda (developed a couple of years ago) and it responds to the needs of the community expressed through several meetings, workshops and field trips. An online co-creation agenda through social media with different scenarios regarding the action will be proposed and the community will express their opinions that will be taken into account.

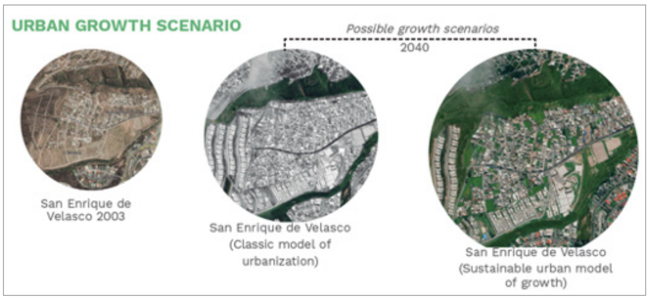
The technical team is working on the proposal for the launch of the co-creation agenda in order to present it to the municipal institutions in charge of implementing.

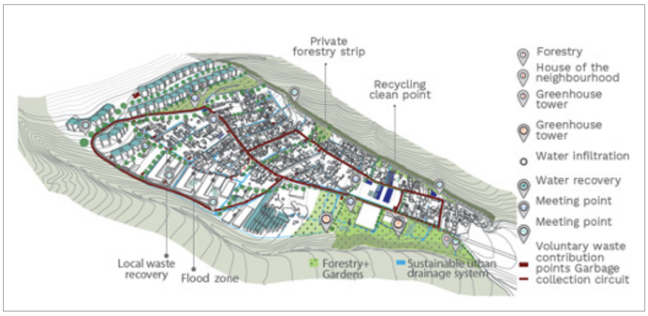
Useful links:
• Clever Cities Project in Quito

Challenges faced

• Limited resources for the implementation of the action despite the demonstrated co-benefits.

• Vulnerable groups might not consider this action as a priority as they might face several challenges related to the COVID19 pandemic. though City partners need to support them in this endeavor.





2. Involving the local community to identify cooling needs and solutions

Quito - continued

'Clever Cities' - working with local communities to identify nature-based solutions

Challenges faced

• The tree planting action does not only involve the revegetation of the neighbourhood and carbon capture but **offers several co-benefits** as the reduction of the average urban temperature, the reduction of number of days with extreme temperatures and the prevention of associated deaths, as well as economic savings associated to the action.

• These actions have **clear urban implications and a direct relation with climate adaptation** measures for the urban heat island effect and soil erosion, and they contribute to soil permeability, the conservation of biodiversity and has landscape benefits as well.

• **Equity is an essential requirement** for the implementation of the tree planting action for the improvement of urban comfort because it might have an unevenly impact depending on various factors such as income level, labour informality, working conditions or age.

Recommendations for other cities

• The development of a **co-benefits analysis of the action is essential** in order to highlight the potential of the action and to get the support from the citizens and from other institutions that might fund the action.

• **Citizen engagement in the co-creation and co-implementation** of the tree planting action is essential and it could be reached through the proposal of different scenarios with and without the action so that they could sense its importance.

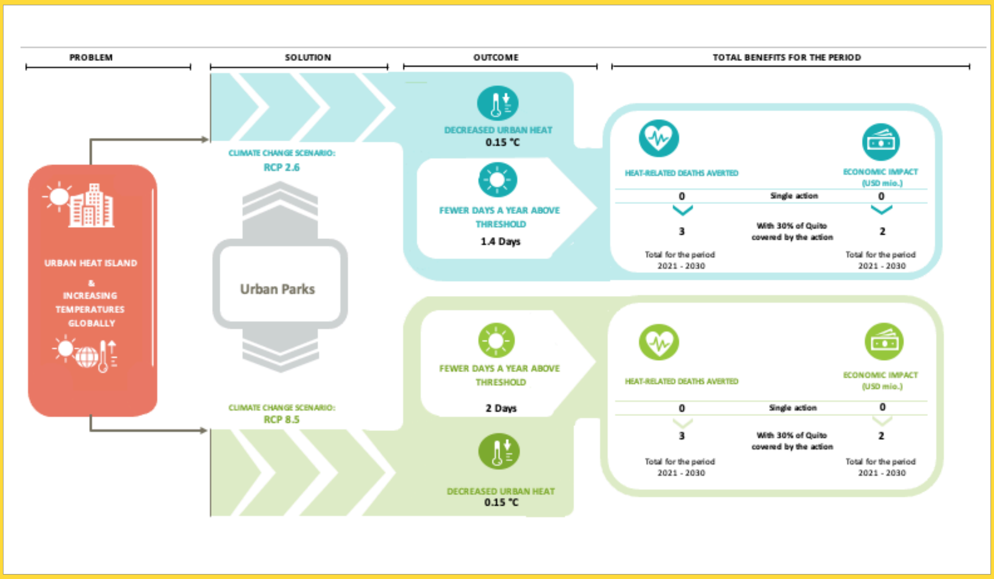
• **Understanding of social dynamics** and the engagement not only with the neighbourhood leaders but with other social groups is essential for the development of the action and for their support in its implementation.

Analysis of co-benefits

As part of the Climate Action Planning process supported by C40, Quito also measured the potential co-benefits of improving the thermal comfort of the Barrio de San Enrique de Velasco with nature based solutions.

The total study area was 66.73 ha and the co-benefits derived from the implementation of the project will benefit 15,101 inhabitants by the year 2040.

The co-benefits have been analyzed through C40's Heat Resilient Cities Tool. You can find the report here (in Spanish).



3. Implementing local-level cooling interventions

Milan

Open Street and Play Streets - using tactical urbanism as a solution to cool down common local spaces

Overview of the Project

Milan's "Open streets and open squares project" is designed to **respond to heat waves and as tools to better share the public and open space**. The approach uses tactical urbanism as a solution to cool down common spaces and foster community response. Some of the open streets were selected to be close to **School Oasis**, in particular with the reclaiming play in the streets, in order to enhance the projects' impacts.wn common local spaces

Key learnings

• **Strong engagement and commitment** of the local community is basic for the results;

• **Usability of the "new" spaces** should be designed on the request of community's needs;

• This is a **pilot action: temporary, low-cost, innovative and with immediate response**. It gives easily a suggestion for eventual scaling-up to a long-term setting up.

Challenges faced

• **Heat waves**, mainly in spring-summer period, with the need of a cool area for sociality;

• **Lack of social spaces**, easy to reach for children and citizens, safe from traffic and protected from air pollution (moreover due to the COVID-effect), affordable for public administration;

• Need for an **innovative and affordable space**, designed on the requirements of each community and each neighborhood, offering multi-benefit impacts on life quality for citizens.

Recommendations for other cities

• Never be afraid of **involving all the actors** (internal and external to the local administration): all of them can support;

• Slowing life (and cars' speed) and opening new spaces **has not to be always expensive**. Trying a new solution with a pilot is a first step to demonstrate that a **new today can become a new everyday**.

3. Implementing local-level cooling interventions

Los Angeles
"Cool Streets LA" - a neighbourhood level project that combines several cooling strategies to help lower local temperatures

Overview of the Project

The programme aims to confront the effects of climate change at the neighbourhood level. Led by StreetsLA, it combines several cooling strategies to help lower temperatures and add shade in L.A.'s hottest and most vulnerable neighborhoods.

The City has completed 'Cool Streets LA' in 5 neighbourhoods with planting **new street trees, installing cool pavement**, installing **bus benches with shade structures**; and providing **hydration stations**. The project also included measuring the actual neighborhood cooling impact using NASA's thermal camera.

Selection criteria for the next phase of neighbourhoods to be included in the programme combines an analysis of the Climate Smart Cities Tool (Trust for Public Land) on climate equity, tree canopy mapping (Google) and community level mapping (location of schools, parks, bus stops, vacant tree wells etc.). In this next implementation phase, over **60 lane-miles of new pavement** will be coated with a cool slurry product and more that **600 tree planting sites have been identified** in eight additional LA neighbourhoods.

Challenges faced

• City budget and staffing limitations placed in response to the challenges that have occurred as a result of COVID.

• **Coordinating with other City Departments** for the inclusion of non-StreetsLA interventions, such as hydration stations.

• Developing thorough and meaningful **community engagement techniques** during COVID restrictions.

Recommendations for other cities

• Selecting neighborhoods by **mapping multiple data sets** including heat islands, underserved communities, and transit-dependent households

• Using **volume purchasing** to drive down the unit costs of cool pavement coatings and demanding longer warrantees

• **Involving community based organisations** in tree planting and watering

3. Implementing local-level cooling interventions

Austin
District Cooling - centralised production and distribution of cooling energy

Overview of the Project

Austin's municipally owned electric utility provider, Austin Energy, offers district cooling service options via **centralized cooling plants and underground chilled water network** piping systems to multiple buildings, residential complexes, hospital, hotels, grocery store and other organizational establishments that prefer alternatives to traditional air conditioning.

Using a chilled water system provides the **high-quality indoor environment** with the greatest reliability for the **least overall cost**. District cooling provides cooling load requirements through the network of underground pipes serving multiple buildings in a service area. A district cooling plant distributes chilled water (approximately 44° to 45°F) to the customer's building through a set of heat exchangers located in a mechanical room.
A single plant can meet the cooling needs of several buildings.

Rendering of Downtown District Cooling Plant #3, to be on-line serving customers in June of 2021 with Art in Public Places installation "Cloud Pavilion".

Austin Energy currently has four district cooling systems: four (4) plants serving downtown Austin; one (1) serving the Domain Redevelopment site; one (1) serving the Mueller Redevelopment site housing the Dell Children Hospital and several other buildings as well as the Austin Community College Highland Campus. The University of Texas at Austin campus also has their own chilled water system.

Benefits:
• Reduce electric **peak demand**
• **Lower capital investment** to client, developer
• **Lower operation & maintenance costs** to client, developer, and customers
• High **reliability** and resiliency.
• Reduce overall power generation and electric distribution infrastructure cost including operational cost over years.
• **Cost savings** on develop electricity infrastructure.
• Designed to meet the **needs of customers**
• Lower **tariffs**
• Overall **aesthetic appearance**
• **Space savings** to client, use of additional real estate to generate revenue

Austin Energy District Cooling Plant #2

3. Implementing local-level cooling interventions

Austin - Continued

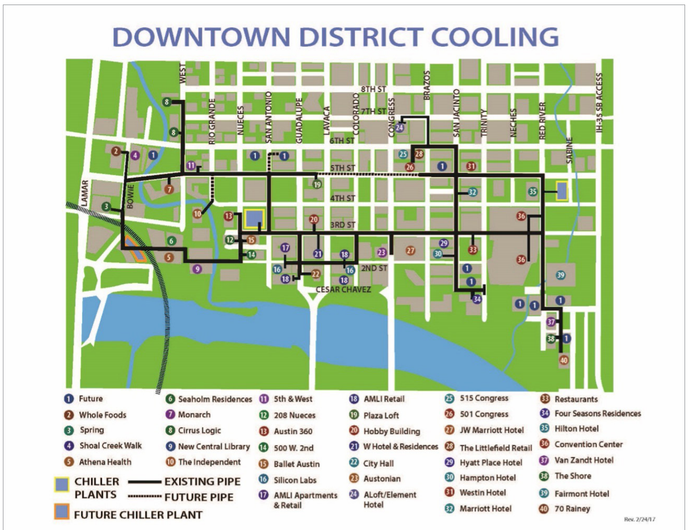
District Cooling - centralised production and distribution of cooling energy

Key learnings

• The **Seasonal Equivalent Efficiency Ratio** (SEER) of the chilled water system is >14, leading to less cost per square foot of air-conditioned space per year.

• Austin Energy's chilled water system **improves overall energy efficiency** using energy storage for electric demand shifting / shaving such as thermal energy storage systems and ICE storage tanks. Both types of storage are charged during the night when electric costs are low. Austin Energy then uses the ice/cold water to provide chilled water the next day between the hours of 3-6PM, the peak electric demand window. This allows large chillers to idle on hot summer afternoons, decreasing the electric load on the entire system during peak demand times.

• By using high-efficiency equipment, an innovative technology, and environmentally friendly refrigerants, which do not deplete the ozone, Austin Energy's chilled water systems **lowers GHG emissions** reducing CO2 emission providing a lower carbon footprint for the Austin area.



Map of Austin's Downtown District Cooling system.

Challenges faced

• **Land area**, finding the space for additional cooling plants in the downtown Central Business District.

• **Infrastructure installation**, working in urban settings/around existing bldgs.

Recommendations for other cities

• **Start early** and integrate system into planned infrastructure

• Work with **developers to invest** in program

• **Promote the benefits** (previous page)

Links to more information:

• Austin Energy - district cooling overview

• Austin Energy - District Cooling Plant #3

• Universtiy of Texas Plant Optimization

Using the URBAN COOLING TOOLBOX to identify local cooling solutions

C40 together with Ramboll developed the Urban Cooling Toolbox that provides a collection of options that cities have to implement cooling actions. Each option is presented on a 'card' and also highlights potential co-benefits and city examples. The cooling options are grouped into six categories:

• **Green infrastructure**, such as trees, green roofs, green corridors and permeable pavements.

• **Blue infrastructure**, including drinking fountains, water cooling, public swimming pools, fountains and water bodies.

• **Grey infrastructure**, such as cool roofs, façade shading, solar window film, cool pavements, and passive cooling in buildings.

• **Communications and outreach**, including cooling centers, outreach and communications campaigns.

• **Policy**, which includes climate design guidelines, heat emergency response plan, cooling tax rebate programmes and cool/green roof regulations.

• **Urban development**, such as urban geometry and building materials.

Download the Urban Cooling Toolbox HERE

GROUND SHADING STRUCTURE

PUBLIC PRIVATE

Any structure that provides temporary or permanent shade from sunlight, thus improving thermal comfort. For example, shading structures can be used on squares, alongside walking and cycling routes, span narrow roads, or to cover street cafe seating. Temporary shades can prevent up to 98% of solar radiation directing onto people and urban surfaces.

KEEP IN MIND

• Movable structures are better so sunlight is accessible in colder months.

Examples:
Tel Aviv's Urban shade initiative
Tokyo Fractal shading
Madrid's Shading structures

Urban cooling toolbox - Grey infrastructure

21

PERMEABLE PAVEMENT (VEGETATED)

PUBLIC PRIVATE

In lieu of traditional pavers, a roadbed composed of a mixture of stones, pavers, and vegetation allows water infiltration of nearly a quarter centimeter per minute. The water stored in the pavement/the soil beneath can evaporate and cool the pavement during summer. Permeable vegetated pavements can be used for footpaths, cycle paths, playgrounds, parking lots, tree pits etc.

KEEP IN MIND

• Porous pavement requires maintenance, typically annually
• Vegetation must be salt and water resilient
• Sensible to drought

Examples:
Barcelona's Green Corridor permeable pavements
Washington DC's Permeable pavement programme for home owners

Urban cooling toolbox - Green infrastructure

4

PUBLIC SWIMMING POOL/ WATER SPRAY PARKS

PUBLIC PRIVATE

A network of public swimming pools provides heat relief to people on hot summer days. Water spray parks are safe water play areas within public parks that use significantly less water than swimming pools. Spray parks are particularly beneficial for children to refresh during heat waves.

KEEP IN MIND

• Water quality & water consumption (especially in drought periods)
• Maintenance of pool facilities
• Small entry fee can create revenue
• Consider tidal pools (where applicable)

Examples:
Berlin's Public swimming pools
Los Angeles' Citywide aquatics and swimming pools
Cape Town's Water spray parks

Urban cooling toolbox - Blue infrastructure

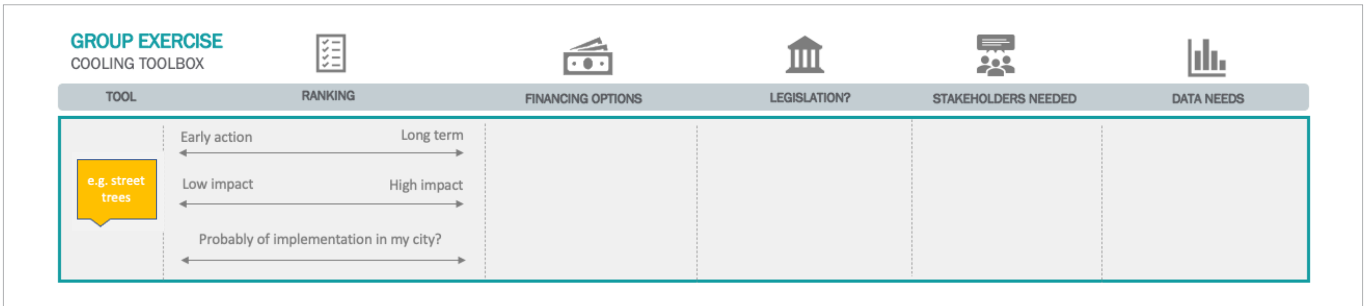
15

Workshop exercise

The Toolbox can be used by city governments at meetings or workshops to discuss and identify different cooling actions your city can take for specific neighbourhoods.

Step 1: Choose in your group a few approriate cooling actions for your local context from the Urban Cooling Toolbox

Step 2: For each action (card), discuss the following cireria:



Acknowledgements

This report was written and designed by Regina Vetter, Cool Cities Network Manager at C40

City contributions by Candace Jordan (Melbourne), Valeria Massy (Buenos Aires), Ines Metelo (Lisbon), Or Aleksandrowicz & team (Israel Institute of Technology) & Rinat Millo-Steinlauf (Tel Aviv), Cheyenne Flores (Philadelphia), Karla Estefania Hurtado Montero (Quito), Marina Trentin & Piero Pelizzaro (Milan), Melinda Gejer & Greg Spotts (Los Angeles), Caitlin Admire & Marc Coudert (Austin).

C40 CITIES

C40.org