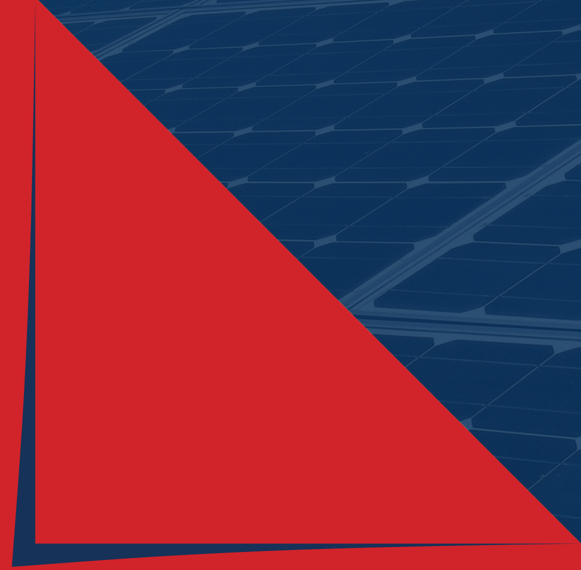


One Million USD in
Design Commissions

# Build Back Solar

## A decade of deployment.

Cities build their share of the great energy transition and lead the way to a sustainable future.

Community Design for Distributed Energy Development

buildbacksolar.org

If we are serious about meeting our carbon emissions targets, cities must take responsibility over the next decade and federal policy must support that effort.

Build Back Solar is a blueprint for immediate implementation that can transform host cities into world-leading net-zero carbon solar cities.

## Project Summary

By merging the fields of community development and solar energy development, Build Back Solar presents an exemplary blueprint for equitable urban solar development. Public funding of soft costs of community engagement and co-design yield shovel-ready contract documents and equitable financing for selected projects.

# Build Back Solar is an international open-call design challenge to establish and catalog best practices for deploying solar power at scale within cities.

**Build Back Solar will demonstrate the feasibility, versatility, and co-benefits of solar landscapes deployed within cities.**

The project will show how the vast social benefits of urban solar integration warrant a shift of focus from remote centralized solar farms to distributed and interconnected systems near population centers. Solar power in cities can simultaneously help to stem climate change and serve as a versatile policy vehicle for addressing issues of environmental justice, energy poverty, wealth inequality, and their intersection with racial injustice.

In addition to being the most viable option from a purely economic standpoint,[1] solar power integrated into the built environment has a multifaceted social return on investment, providing co-benefits for cities that can be easily quantified.

In order to highlight this unique historical opportunity, and aligned with the Biden-Harris campaign to Build Back Better during their administration, Build Back Solar will launch an interdisciplinary design challenge in 2023, beginning with the first host city and expanding to more cities over the next decade.

It can be challenging for people to imagine what solar infrastructure can look like in the city beyond rooftop installations. A great benefit of this design challenge will be to provide an illustrated window onto our sustainable future, where solar co-exists with urban gardens, places of worship, public plazas, riverwalks, reservoirs, and many other urban site typologies.

**Of the hundreds of site-specific proposals that will be submitted to the first Build Back Solar open call design challenge, a shortlist will be provided with a suitable stipend to develop their design, execution, and financing strategy, readying the winning projects for immediate construction.**

The Build Back Solar inaugural host city will be transformed over the next decade into a solar capital of the world and will stand up as a global climate leader, setting a precedent for cities around the world. As Build Back Solar expands throughout the 2020s, the project will transform many other host cities into solar energy hubs to benefit people and the planet.

**1** https://www.vibrantcleanenergy.com/wp-content/uploads/2020/12/WhyDERs_TR_Final.pdf

**2** https://www.localsolarforall.org/roadmap

# Over the next decade the world will experience massive and unprecedented development of solar power infrastructure.

| 2022 | 2023 Spring & Summer | 2023 Fall & Winter | 2024 |
|---|---|---|---|
| Community meetings.<br>Meetings with the city and other project partners.<br>Establish sites.<br>Research design constraints.<br>Hold meetings with site stakeholder groups to gather ideas for inclusion in the design brief.<br>Marketing campaign to spread awareness.<br>Gather documentation and supplementary materials for each site. | Launch the design process.<br>Community meetings.<br>Establish design delivery model: co-design, RFP, design competition, etc.<br>Distribute call to design teams (design brief).<br>Public outreach events and educational programs.<br>Iteration of design based on community feedback.<br>Selection process for competitions. | Exhibitions of designs.<br>Selected design teams contracted to bring concept forward through detailed design for bid and construction.<br>Continuing public engagement and educational outreach.<br>> 10 MW of shovel ready city-integrated solar projects with community co-benefits. | Developers awarded contracts on successful bids.<br>Community feedback and approval of final development plans.<br>Construction of awarded projects complete by the fall of 2024.<br>Opening of the next iteration of Build Back Solar in the next host cities. |

Solar energy is now the cheapest form of energy on the planet,[1] and as its price continues to fall it has become the go-to technology for new energy supplies.

**Projections suggest that to achieve carbon neutrality and prevent the worst impacts of climate change, the U.S. will add hundreds of gigawatts of new solar energy to power future urban electricity demand.**

Solar will also play a key role in providing the energy necessary to power electric vehicles cleanly and to supply green electrons for industry.

Solar development will inevitably include large, utility-scale power plants in remote locations that transmit electricity to cities over long-distance transmission lines. But the parallel path for large-scale urban solar development holds great potential.

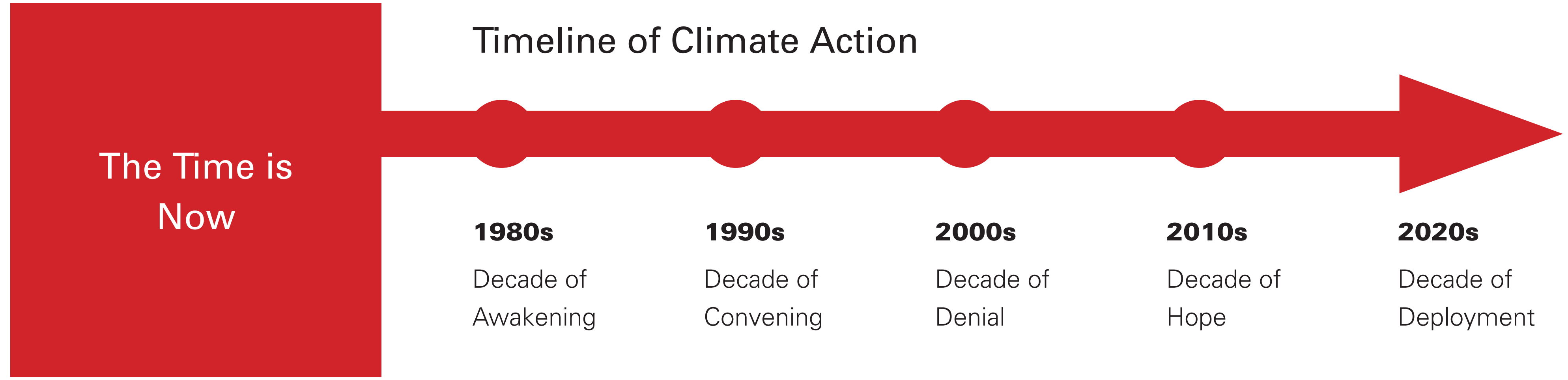
How can cities and towns take advantage of the opportunity to deploy solar energy inside their own boundaries in ways that enhance not only urban sustainability but also urban livability, resilience, beauty, food security, racial and economic justice, and economic development. These co-benefits make the prospect of building solar cities an exciting and potentially transformative investment for municipalities, electric utilities, foundations, and others looking for ways to leverage social innovation and socially responsible investing to create better futures for cities and the communities that inhabit them.

1 https://webstore.iea.org/world-energy-outlook-2020

**How can we accelerate the deployment of solar power infrastructure for cities in ways that enhance diverse social, economic, and environmental benefits for urban communities while also ensuring that the net costs and benefits of that development are (1) comparable to those for remote and rural utility-scale power plants; and (2) equitably distributed across communities?**

How can coordinated city-wide solar projects enhance local culture, enliven public spaces, and provide other extensive co-benefits? Can urban solar innovation benefit economically disadvantaged communities or help reverse historical patterns of urban racial or economic injustice? Are there ways of aggregating rooftops, public spaces, empty lots, brownfield sites, parking lots, and other viable sites within the city to create large-scale urban projects for procurement, taking advantage of similar economies of scale as large rural projects? What kinds of financing mechanisms could be developed to expand the pool of investors and beneficiaries? Can the universal resource of solar energy be managed in such a way as to accrue benefits universally to all the people? What would all of that solar infrastructure look like, and how could it be culturally and aesthetically integrated into urban visual-scapes and enhance the public commons?

There are a number of companies and innovators that have developed products specifically for solar integration into a wide range of urban spaces, including residential and commercial rooftops, parking garages, parks, walking areas, and more. The Build Back Solar design challenge is an opportunity for these organizations to showcase their products for site-specific solutions while also providing a platform for innovation by startups, design firms, and individual creatives.




According to the Solar Energy Industries Association (SEIA) and Wood Mackenzie, the United States deployed a record 19 GW of solar photovoltaic capacity in 2020 in spite of the coronavirus economic recession.[1] Solar power is fast becoming the leading type of new energy deployment, outpacing natural gas and comprising 43% of all new electric generating capacity additions.

**If we are to meet the goals that climate scientists agree we have to meet, we will need to accelerate even more rapidly. 19 GW might sound like a lot, but a net zero emissions global economy may require fifteen hundred times that capacity.**

1 https://www.woodmac.com/research/products/power-and-renewables/us-solar-market-insight/

**As we enter the 2020s (the decade of deployment), city strategic planning must consider the impact and opportunity that the global deployment of 110 billion solar modules will have on our cities, our economies, and our cultures.**

Many solar modules will be installed on rooftops but not all rooftops are suitable. Cities could choose to outsource their solar power, import it from less densely populated areas with massive centralized solar farms. But what about the impact of these inland seas of solar panels and transmission lines on the use of public lands, on natural habitats, forests, lower income communities, scenic landscapes, tribal lands, agriculture, recreation, and future development? Would it be preferable to generate power closer to where we use it?

Centralization of remote power plants and energy distribution infrastructure are a consequence of fossil fuel and nuclear power logistics. You can't have rooftop coal powered electricity. It demands economies of scale. Solar works the same at any scale. And when we distribute solar nearer to the places it is consumed, we increase resilience, reduce transmission losses, and we can take advantage of an interconnected microgrid with storage, demand management systems, etc.

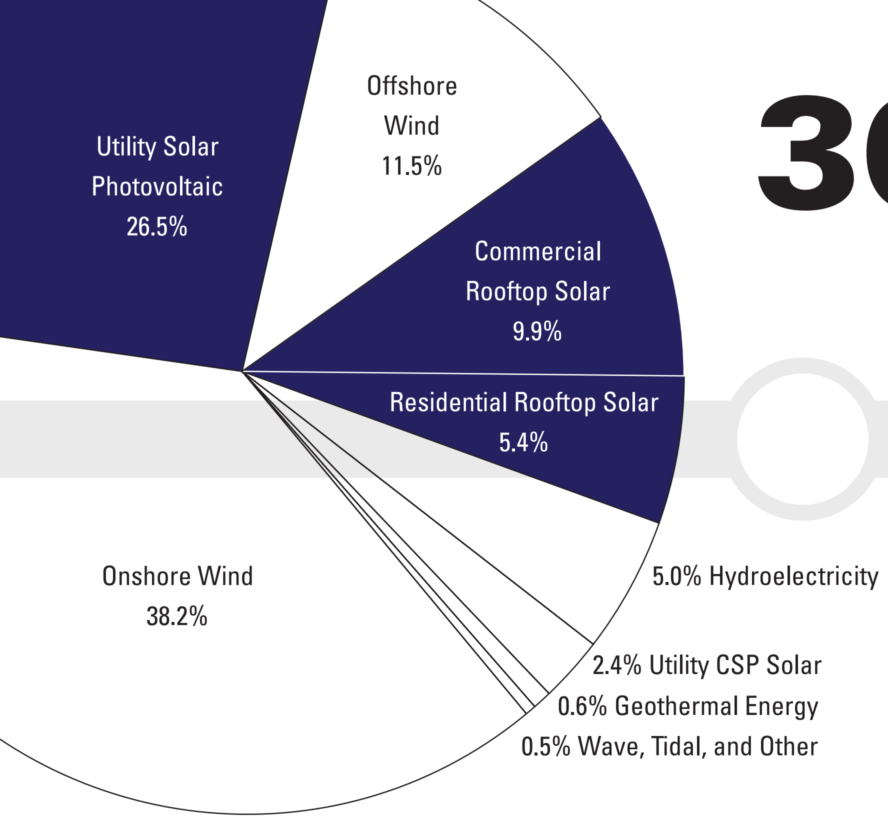
If we decide that it is preferable that cities deploy solar energy landscapes in proportion to their consumption of energy rather than import it from the countryside, then we will want to find creative and equitable ways to bring solar energy landscapes into urban areas. As we have seen with the affordable housing crisis in America, one of the most serious obstacles to implementation of solutions in cities is often local community pushback, even by folks who are in favor of the larger social goals.

Build Back Solar is designed to set a standard for community engagement during the early design process for solar projects in cities.

There are 1,050 cities in the world with populations over 500,000 people.

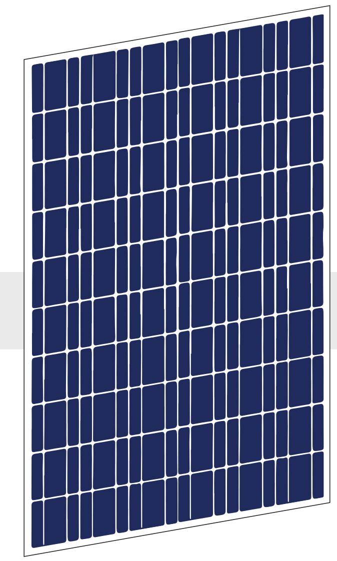
**Over the course of this decade, these 1,050 cities will lead the way to climate balance by installing solar energy to meet their proportion of the global energy demand in a 100% renewable energy economy.**

Build Back Solar will begin in 2023 with the first host city. Each following year of the annual design challenge, the number of host cities will expand exponentially until the early years of the 2030s when every city in the world could generate its solar share of net-zero energy within its boundary.




# 30,000 gigawatts

To achieve a world entirely powered by renewable energy we may need to install 30,000 gigawatts (GW) of photovoltaic solar capacity globally as a part of a mixed portfolio of solar, wind, and hydro energy resources with robust energy storage. That's 110 billion solar modules.



# 110 billion

Number of standard size solar modules required to meet the necessary capacity. Divided by the world population, this comes out to about 14 solar modules per average human on the planet. It could be argued from an equity perspective that richer nations and cities take an even greater share per capita.

What is a City's Share?

# 180,000 square kilometers of solar modules

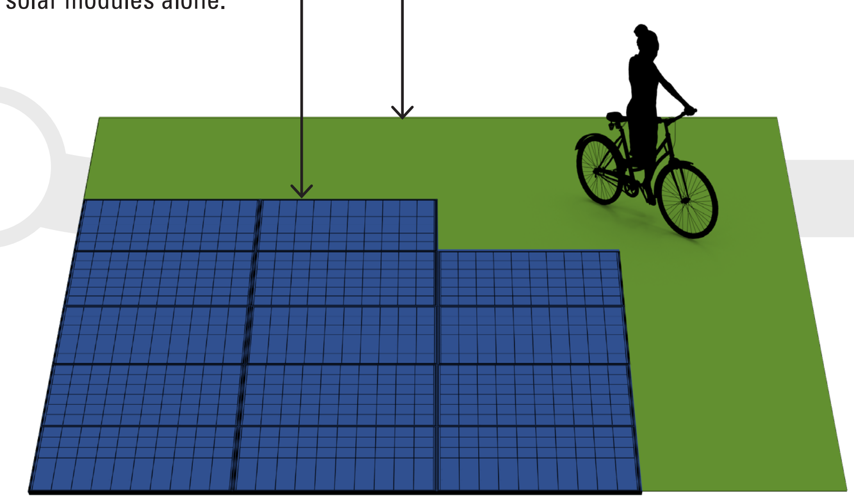

Land area that would be covered by 110 billion solar modules placed frame-to-frame with no space between.

## The land use impacts of solar power are significant. It's time for cities to take the lead.

# 44.62 square meters

Area of installed solar energy landscape required per per person* to successfully achieve the energy transition and reach net zero. (4.2 kW capacity)

*assuming a total world population of 7.8 billion people and an equal distribution of responsibility.




# 348,000 square kilometers of solar energy landscape


Land area that would be covered by 110 billion solar modules installed as energy landscapes (includes space between the modules and space for auxiliary equipment and maintenance areas). Equal to the area of Germany.

## Co-benefits of Solar for Cities

food security, shading, water security, public health, poverty alleviation

# Solar cities will have major competitive advantages over non-solar cities.

Replacing fossil fuel infrastructure in cities improves air quality and quality of life.

Solar panels installed over:

- canals and reservoirs can increase flow throughput by decreasing evaporation.
- community gardens can collect rainwater for irrigation and expand viable urban agriculture sites in dryer regions, all helping to contribute to food security.
- public spaces can help to reduce heat island effects and risk of heat stroke in summer.

Providing carbon free energy in the fight against climate change is the most obvious benefit of solar power. What may be overlooked are the benefits of distributed solar for local economies and as a mechanism to increase social equity and quality of life. Properly planned and implemented, city-integrated solar infrastructure can provide a wide array of co-benefits.

### Energy Resilience and Independence

The application of solar infrastructure can increase the energy independence of municipalities. Cities are already taking advantage of long-term power purchase agreements for clean energy to establish pricing stability. By bringing solar installations into urban neighborhoods, cities can accomplish the same goal while also contributing to resilience and efficiency by limiting reliance on monopoly utilities and eliminating maintenance costs for remote distribution infrastructures. Localized supply chains can emerge to provide good paying jobs while decreasing the embodied environmental footprint of solar modules.

### Solar Dividend

The energy of the sun is a universal natural resource. Throughout history there are examples of a "universal property" approach to the distribution of natural resource benefits. The most often cited example is the Alaska Permanent Fund. Writing in *Scientific American* James Boyce summarizes the program:

> In 1976, as oil production commenced on Alaska's North Slope, the state amended its constitution to create a new entity called the Alaska Permanent Fund. The idea was the brainchild of Republican governor Jay Hammond, who believed that Alaska's oil wealth belonged to all its residents, and that all should receive equal annual dividends from its extraction.[1]

The idea extends to the principle of the "solar energy commons"—a recognition that the sun's energy belongs to all of us if it belongs to any of us. Especially when installed on public land or community land trusts, solar power offers an opportunity for an equitable distribution of a solar dividend, a policy mechanism that can be a powerful tool to combat the cycles of poverty experienced by so many the world over. The sale of solar electricity can pay out in universal basic income[2] and provide new opportunities for private wealth generation through distributed energy ownership, a democratization of what is today almost entirely monopoly ownership.

Technologies such as virtual net metering make it possible for individuals to become energy "prosumers" selling kilowatt-hours directly. As privatization of solar infrastructure becomes more widespread it will be important to make sure that the financial benefits are not limited to the upper class, but intentionally provide diversity of ownership as a means to close the wealth gap.

### Quality of Life

When designed in collaboration with communities, solar installations can improve quality of life and the beauty of public spaces. PV modules can provide aesthetic shade, creating new microclimates that expand the comfort zone in hotter climates into the summer months for human activities in outdoor public spaces.

Cities have the opportunity to define themselves and to instill a sense of pride and ownership of our shared energy infrastructures by creating new visual icons and cultural markers of what solar looks like for their city.

Solar technology is a versatile design medium that can take shape in a variety of styles and expressions that capture the vibe of local cultures. More vibrant and livable cities attract more business and investment. They retain people over generations and attract new long-term residents.

A city that has installed its share of solar infrastructure will have a competitive advantage over cities that have not yet done so.

**Solar cities will tend to be more livable, equitable, innovative, and resilient—all qualities that make for strong economic development.**

1 https://www.scientificamerican.com/article/the-case-for-universal-property/
2 https://sustainablesystemsfoundation.org/ending-poverty-in-california-through-solar/

Site Typologies

# Within the city's municipal boundaries there are a number of sites that could double as solar energy landscapes.

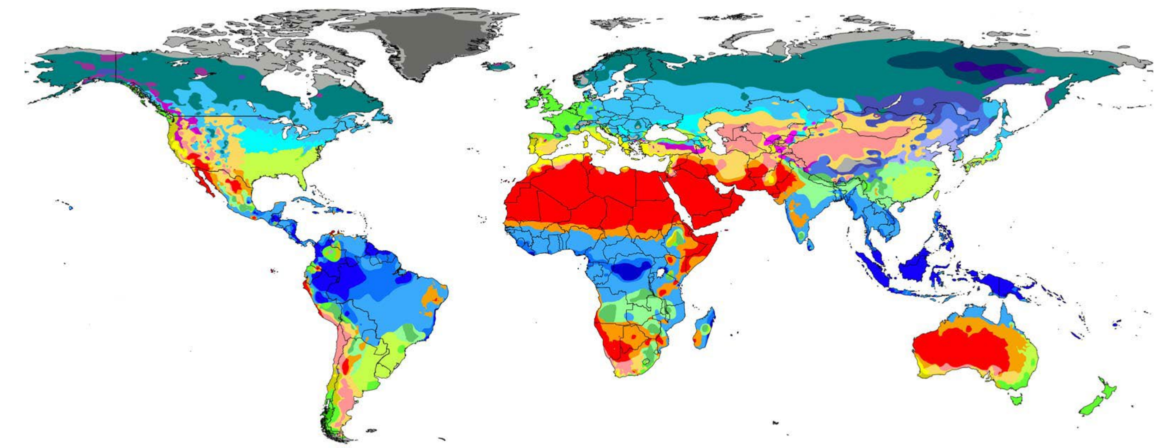
The introduction of solar to some of these sites typologies can provide the added benefit of shading to extend the public use of spaces into the summer months.

## Site typologies include urban and suburban areas.

- Airport
- Brownfield
- Commercial plaza
- Community center
- Community garden
- Landfill, transfer station, or other waste management site
- Parking lot
- Place of worship
- Public park
- Public school
- Reservoir
- Riverfront
- Rooftop (residential, multi-family, big box commercial, industrial)
- Transportation corridors (bike lanes, bus routes, railroad, etc.)
- University
- Urban farm
- Urban substation
- Vacant lot
- Water treatment site

# Build Back Solar will eventually provide a blueprint for equitable solar integration for cities representing all of the world's climate typologies.

Climate Typologies



**WET EQUATORIAL**
Jakarta, Kuala Lumpur,
Rio de Janeiro, San Juan

**TROPICAL MONSOON**
Bangkok, Lagos, Rangoon,
Manilla, Brazilia

**TROPICAL WET-DRY**
Havana, Caracas, Chennai, Mumbai

**TROPICAL AND SUBTROPICAL DESERT**
Dubai, Cairo, Muscat, Basra, Riyadh

**MID-LATITUDE STEPPE AND HIGH DESERT**
Phoenix, New Delhi, Shiraz, Jaipur, Madrid,
Reno, Denver

**TROPICAL AND SUBTROPICAL STEPPE**
Tehran, Madrid, Perth, Sacramento, Algiers,
Capetown

**HUMID SUBTROPICAL**
Bogota, Shanghai, Sao Paulo, Atlanta,
Miami, New Orleans, Houston,
Los Angeles, San Diego

**MEDITERRANEAN**
Rome, Istanbul, Lisbon, Barcelona,
Tel Aviv, San Francisco

**OCEANIC**
Paris, London, Seattle, Portland, Vancouver,
Melbourne, Canberra, Aukland, Wellington

**HUMID CONTINENTAL**
Tokyo, Moscow, Helsinki, Copenhagen,
Vienna, Berlin, New York, Boston, Detroit,
Chicago, Pittsburgh

**CONTINENTAL SUBARCTIC**
Oslo, Juneau, Anchorage, Reykjavik)

**HIGHLAND**
n/a-small villages only

**TUNDRA**
n/a-small villages only

**SNOW AND ICE**
n/a-few permanent settlements

Climate typologies are from the Köppen climate classification map.
https://www.britannica.com/science/Koppen-climate-classification/World-distribution-of-major-climatic-types

# Process

- With broad community collaboration, BBS will identify several suitable sites over a total of 75 acres in each host city that will come together in a coordinated design for a total 30 megawatts (MW) of solar power infrastructure. By aggregating a utility-scale project (65,000 commercial solar panels) across multiple sites, the project will meet the kind of economies of scale that are standard for exurban installations while bringing greater resilience and reliability to the city grid, directly conserving 75 acres of countryside, and bringing a suite of co-benefits to neighborhoods.
- BBS will be managed by a consortium of project partners representing the fields of sustainable community design and planning; diversity, equity, and inclusion; solar energy policy; land use law; ecology and biodiversity; geography and spatial analysis; riverfront and reservoir development; marketing and communications; and education and outreach.
- This consortium will coordinate closely with local stakeholders, including city and county commissions, local community groups and development corporations, elected officials, utility companies, regulatory agencies, and individual citizens.

## Stage 1

- The first phase of work will include a spatial analysis and solar survey; establishment of legal constraints; outreach to solar developers and market experts; meetings with city officials; and recommendations for inclusive financing models. Partnerships will be established with 24 local community representative organizations who will assist in coordinating public events and design workshops.
- Community engagement begins with an initial meeting with community leaders, followed by a public presentation of the idea and open discussion. Subsequent meetings will include interactive mapping; storytelling; site selection and analysis; co-benefit ideation workshops; procurement strategy; solar financing and equity workshops; and the co-creation of the design brief documents with key members of the community. At any step of the process a community can decide how to participate in the project, or not to participate at all.
- An open call international design challenge will be at the heart of the overall program. For the communities who have decided to participate, BBS will launch an interdisciplinary design challenge following 18 months of community engagement. In parallel, some communities may opt to engage in a community co-design project with a local artist or designer.
- The unique design briefs for each of the sites will reflect the stated aspirations of each community for shared land uses and co-benefits of community solar.
- Based on the participation levels of past Land Art Generator design competitions, hundreds of participating design teams will respond to one or more of the site-specific design briefs with concept design proposals that illustrate the idea and outline the co-benefits of the shared land use.
- At the conclusion of the design challenge, the community juries will select their preferred project for each of the selected sites. The project will unveil all the design proposals to the world through exhibitions, publications, and media coverage, presenting an exemplary blueprint to the world for equitable urban solar development. Projects will be selected by community representatives to receive detailed design commissions.
- By supporting the development of community-driven bid packages, the soft costs and risks of development are removed from the balance sheets of the solar energy developers who will come forward to install the projects that are selected by local stakeholders.
- With their soft costs covered and with the good will and support of the communities within which they will be working, energy developers are therefore strongly incentivized to invest in urban solar projects while the BBS design brief ensures that an equitable and just transition is a centerpiece of each project plan.
- The initial investment by the public sector in BBS will cover the cost of the community engagement, design challenge, selection process, co-design, construction documents (design and engineering), and permitting. The public sector investment thus functions as a kind of subsidy to the development of socially responsible solar energy landscapes within population centers.

- Following the selection of the concept designs for each site, detailed design proposals are solicited, and the architecture and engineering (A/E) firms are chosen to develop documents for fabrication and construction. At each step in the detailed design process, the community will be re-engaged through a series of public presentations and workshops coordinated by the A/E.
- Community design workshops to develop the concept with community
- Initial workshop to present concept and solicit feedback and ideas
- Presentation of design development drawings and renderings
- Presentation of draft bid package
- Detailed design drawings, specifications, and bidding/negotiation contract documents
- Project execution plan presentation detailing net present value, return on financial investment, sustainable site business model, life-cycle analysis, operations and maintenance plan, embodied carbon payback period, site environmental impact assessment, social value assessment, and financing strategy.
- With all the soft costs of community engagement and detailed design covered by the public sector, solar developers will bid on the projects that can be categorized at this stage as "Notice to Proceed," the lowest risk investment for solar development. Tenders for development will include the specific requirements for solar developers to meet the standards of equity, inclusion, and co-benefit of land use established by each community.

Stage 2

Stage 3 will focus on the construction of the winning entries as permanent installations in the built environment. The installations will be of such an aggregated scale that they will provide a sizable contribution to the overall decarbonization goals of the host cities.

Stage 3

# Build Back Solar will be strategically implemented with the goal of scalability and replicability for rapid global deployment.

Build Back Solar will establish an exponential growth pattern for city deployment by implementing a customized development model that allows for enfranchisement, open source documentation, and typological replication.

Each serving host city will serve as an organizational hub for the future planning and deployment of 2–4 additional host cities for Build Back Solar design challenges. In this way, the initiative has the potential to reach more than 1,000 cities across the globe by the end of the decade.

## Scaling

NIGHT & DAY

**DESIGNERS**
Kevin Kudo-King, Annie Aldrich, James Juricevich, Evan Harlan, Vikram Sami, Erin Hamilton, Gabriela Frank, MacKenzie Cotters, Lauren Gallow, Jonathan Nelson (Olson Kundig)

**TECHNOLOGIES**
mono-crystalline silicon photovoltaic, pumped hydro storage

**ANNUAL CAPACITY**
1,000 MWh

Second Place Winner of the 2018 Land Art Generator Initiative design competition for Melbourne—LAGI 2018.

## The Multiplier Effect of Build Back Solar

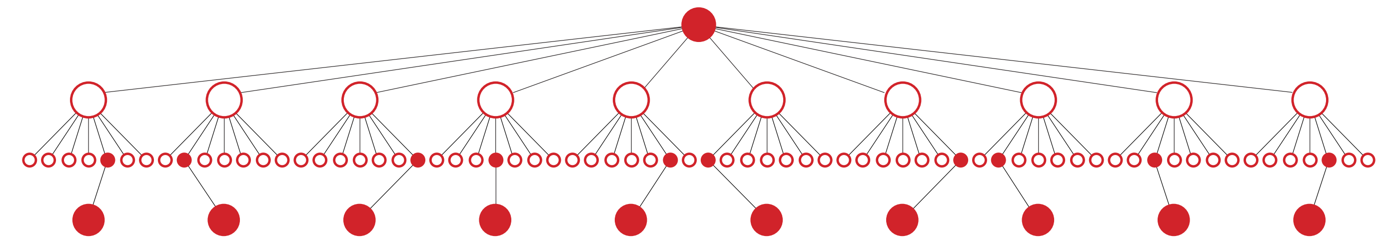
By harnessing the power of the private solar market, the initial investment in Build Back Solar results in the installation and long-term maintenance of more $20 million in solar infrastructure (~20 MW capacity) at no cost to the city or to program sponsors.

That is more than **ten times** the quantity of solar capacity that could be installed by conventional methods. By covering the soft costs of development, developers are incentivized to invest in city solar projects while Build Back Solar will ensure that an equitable and just transition is a centerpiece of each project plan.



## Budget

Stage 1 initial investment leads to hundreds of beautiful and equitable design proposals submitted by design teams from around the world.



Stage 2 covers developer soft costs for detailed design, site approval, and financing documents for ten projects—one for each site, and all chosen by local stakeholders. Developers are obligated per the terms of the bid to pass along the soft cost savings to social justice initiatives and site co-benefits.

| | |
|---|---|
| $750,000 | Consultants and project management including: design guidelines development, project management, marketing, GIS, research, site analysis, energy consultant, community engagement consultant, and equity consultant to oversee the project agenda of a just transition. |
| $185,000 | Community outreach including: public programming, exhibitions, events, stakeholder engagement, educational materials, workshops, documentary publication & distribution. |
| $65,000 | Expenses including: travel and information technology |
| $1,000,000 | *Stage 2 development funding (bid documents) |
| **$2,000,000** | Total (detailed budget available on request) |

The construction funding is outside of the scope of Stage 1 and Stage 2 of Build Back Solar, as it will be provided by the investor owners (hopefully community cooperatives) of the new solar infrastructure who will profit over time by the sale of clean kilowatt-hours, investment incentives, and renewable energy credits.

Land Art Generator is a 501(c)(3) nonprofit registered in the United States. Donations are tax-deductible per IRS.

# City of Phoenix

CLIMATE TYPOLOGY **MID-LATITUDE STEPPE AND HIGH DESERT**

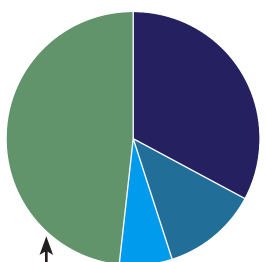
POPULATION **1,680,992**

CITY AREA **1,345 $km^2$**

CITY SHARE OF SOLAR AREA **75.01 $km^2$**

**(44.62 $m^2$ per person)**

Example City



## 75.01 km2

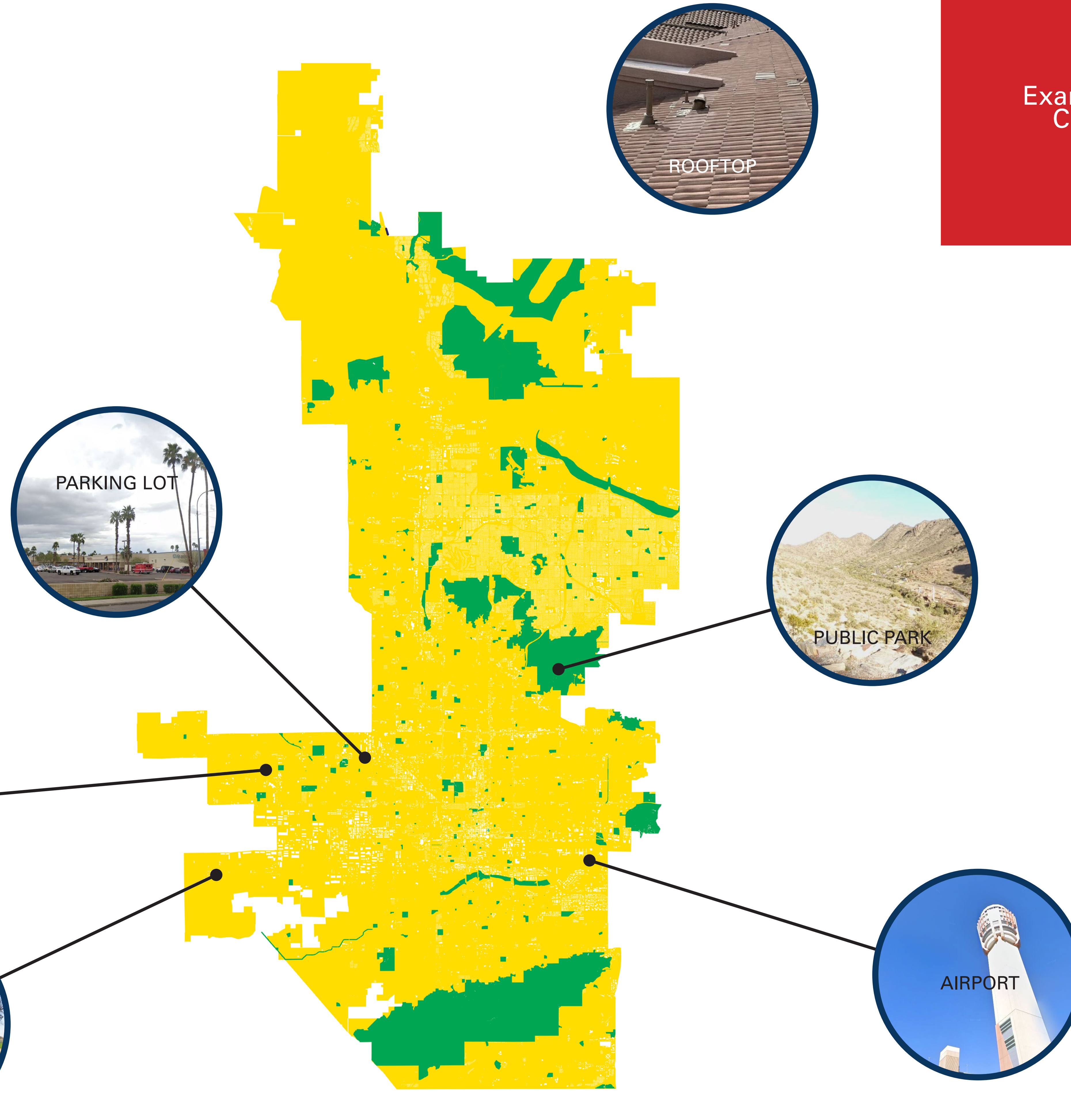
Phoenix's Share of Solar Responsibility

## Percent of City

| | |
|---|---|
| Landscape* Solar | 1.83% |
| Commercial Rooftop PV | 0.68% |
| Residential Rooftop PV | 0.37% |
| Supporting Space | 2.69% |
| Total | 5.58% of Phoenix |

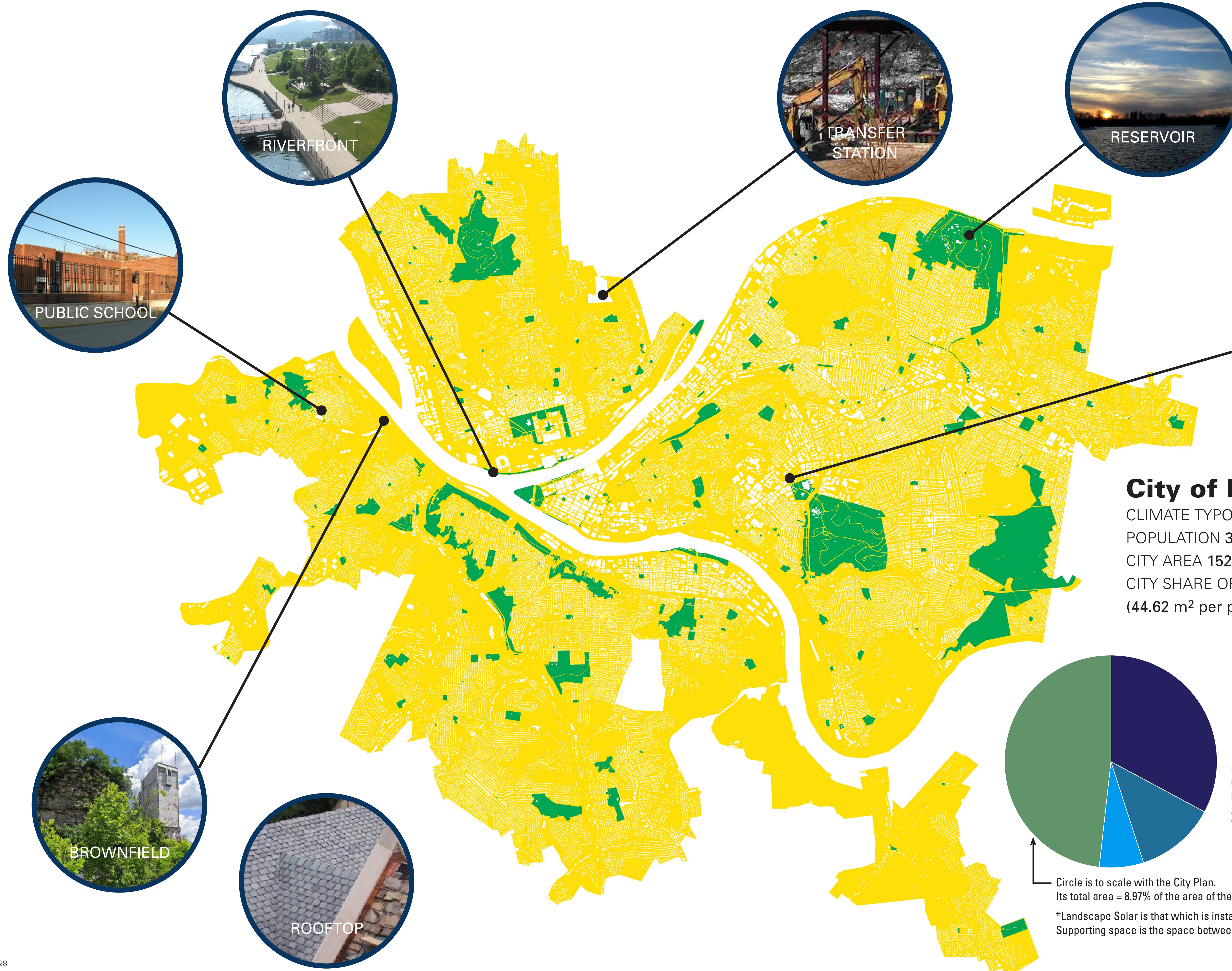
Circle is to scale with the City Plan.
Its total area = 5.58% of the area of the City.

*Landscape Solar is that which is installed anywhere other than on rooftops.
Supporting space is the space between modules required for servicing and to maximize performance.





## Example City





# City of Pittsburgh

CLIMATE TYPOLOGY **HUMID CONTINENTAL**

POPULATION **305,704**

CITY AREA **152 km$^2$**

CITY SHARE OF SOLAR AREA **13.64 km$^2$**

**(44.62 m$^2$ per person)**

## 13.64 km2

Pittsburgh's Share of Solar Responsibility

## Percent of City

| | |
|---|---|
| Landscape Solar* | 2.94% |
| Commercial Rooftop PV | 1.10% |
| Residential Rooftop PV | 0.60% |
| Supporting Space* | 4.33% |
| Total | 8.97% of Pittsburgh |

Circle is to scale with the City Plan.
Its total area = 8.97% of the area of the City.

*Landscape Solar is that which is installed anywhere other than on rooftops.
Supporting space is the space between modules required for servicing and to maximize performance.

LIGHT UP

**DESIGNERS**
Martin Heide, Dean Boothroyd, Emily Van Monger, David Allouf, Takasumi Inoue, Liam Oxlade, Michael Strack, Richard Le (NH Architecture); Mike Rainbow, Jan Talacko (Ark Resources); John Bahoric (John Bahoric Design); Bryan Chung, Chea Yuen Yeow Chong, Anna Lee, Amelie Noren (RMIT students)

**TECHNOLOGIES**
flexible mono-crystalline silicon photovoltaic, wind energy harvesting, microbial fuel cells

**ANNUAL CAPACITY**
2,220 MWh

First Place Winner of the 2018 Land Art Generator Initiative design competition for Melbourne—LAGI 2018.

## Project Lead



The Land Art Generator is the world leader in renewable energy design competitions, with over a decade of experience hosting city-based competitions for iconic renewable energy installations as a form of public art. Their competitions have been hosted by some of the world's leading cities: Dubai, Abu Dhabi, Santa Monica, New York, Copenhagen, Melbourne, and most recently Fly Ranch—4,000 acres near Black Rock City owned by Burning Man Project. Participants in LAGI competitions have included some of the world's most influential design and architecture firms and university design schools.

Additionally, the Land Art Generator produces free educational materials, provides workshops and STEAM programming to educators, and publishes reference guides and information graphics on renewable energy technologies and land use implications. The mission of the nonprofit is to accelerate the transition to a regenerative and renewable economy by inspiring the world about the beauty of a post-carbon tomorrow.

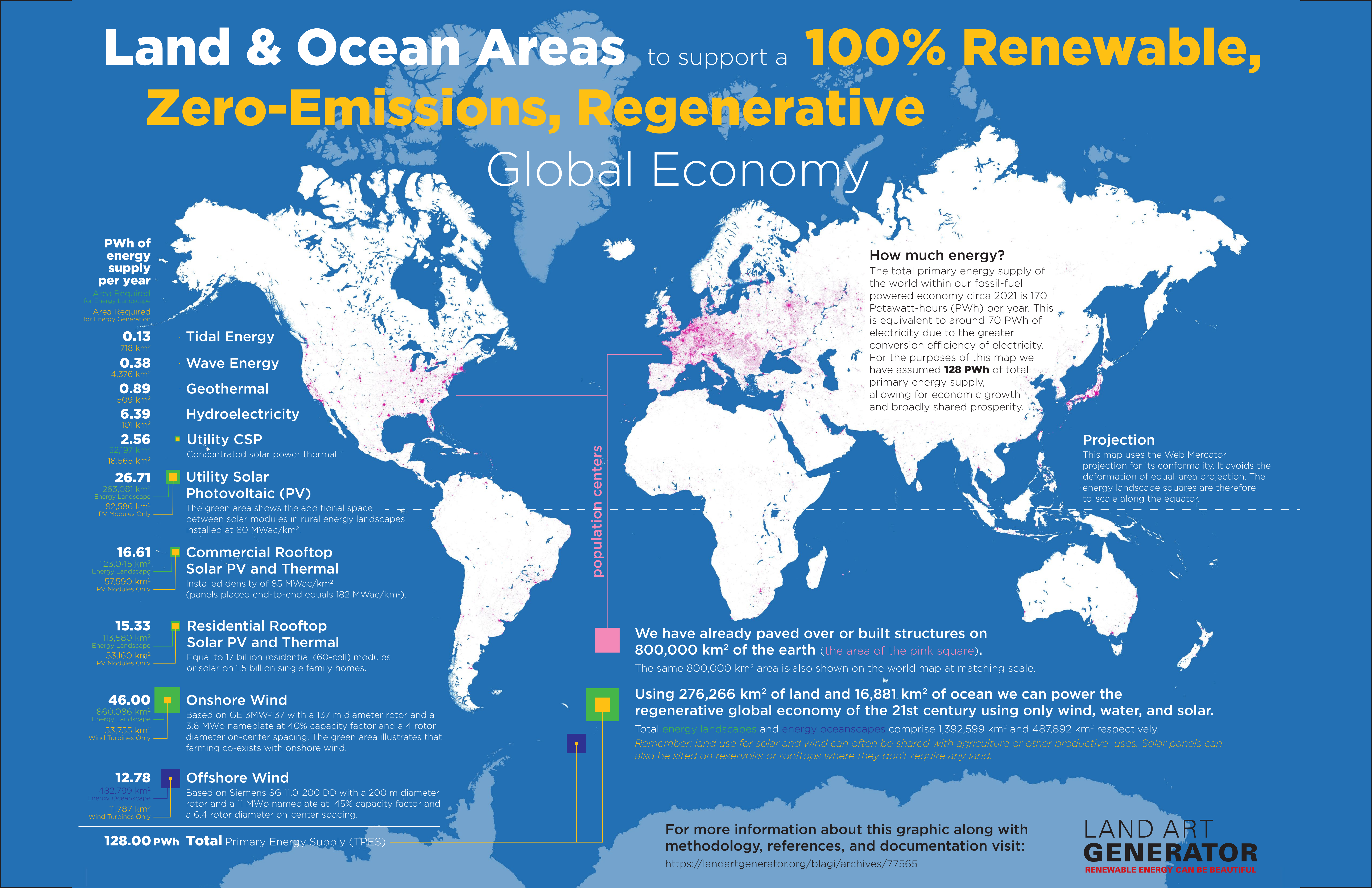
Partnerships and supporters include Masdar Abu Dhabi, City of New York, NYC Department of Parks and Recreation, City of Copenhagen, European Union Commission on Climate Action, City of Santa Monica, J.M. Kaplan Fund, National Endowment for the Arts, Capital Region of Denmark, Danish Design Centre, US Green Building Council, the City of Glasgow, the State of Victoria (Australia), Carbon Arts, Creative Carbon Scotland, Climarte, Burning Man Project, Arizona State University (GIOS), Zayed University, IT University of Copenhagen, and many others.

Land Art Generator publications include *The Time is Now: Public Art of the Sustainable City* (2012, Page One Publishing), *Regenerative Infrastructures* (2013, Prestel Publishing), *New Energies* (2014, Prestel Publishing), *Powering Places* (2016, Prestel Publishing), *Energy Overlays* (2018, Hirmer Publishing), *Return to the Source* (2019, Prestel Publishing), and *A Field Guide to Renewable Energy Technologies* (1st edition 2012, 2nd edition 2019).

The 2009 Land Art Generator information graphic *Surface Area Required to Power the World with Solar* helped to influence the popular imagination of what a post-carbon world might look like. It was published by the *International Energy Agency in their 2011 Solar Energy Perspectives* report. Since then, the Land Art Generator has published many more information graphics from comparisons of land use impacts from fossil fuel extraction and renewable energy production to mapping the land area of solar required to power bitcoin.

https://landartgenerator.org

# Land & Ocean Areas to support a 100% Renewable, Zero-Emissions, Regenerative Global Economy




**PWh of energy supply per year**
Area Required for Energy Landscape
Area Required for Energy Generation

**0.13** Tidal Energy
718 km²

**0.38** Wave Energy
4,376 km²

**0.89** Geothermal
509 km²

**6.39** Hydroelectricity
101 km²

**2.56** Utility CSP
32,197 km²
18,565 km²
Concentrated solar power thermal

**26.71** Utility Solar Photovoltaic (PV)
263,081 km² Energy Landscape
92,586 km² PV Modules Only
The green area shows the additional space between solar modules in rural energy landscapes installed at 60 MWac/km².

**16.61** Commercial Rooftop Solar PV and Thermal
123,045 km² Energy Landscape
57,590 km² PV Modules Only
Installed density of 85 MWac/km² (panels placed end-to-end equals 182 MWac/km²).

**15.33** Residential Rooftop Solar PV and Thermal
113,580 km² Energy Landscape
53,160 km² PV Modules Only
Equal to 17 billion residential (60-cell) modules or solar on 1.5 billion single family homes.

**46.00** Onshore Wind
860,086 km² Energy Landscape
53,755 km² Wind Turbines Only
Based on GE 3MW-137 with a 137 m diameter rotor and a 3.6 MWp nameplate at 40% capacity factor and a 4 rotor diameter on-center spacing. The green area illustrates that farming co-exists with onshore wind.

**12.78** Offshore Wind
482,799 km² Energy Oceanscape
11,787 km² Wind Turbines Only
Based on Siemens SG 11.0-200 DD with a 200 m diameter rotor and a 11 MWp nameplate at 45% capacity factor and a 6.4 rotor diameter on-center spacing.

**128.00 PWh Total** Primary Energy Supply (TPES)

### How much energy?

The total primary energy supply of the world within our fossil-fuel powered economy circa 2021 is 170 Petawatt-hours (PWh) per year. This is equivalent to around 70 PWh of electricity due to the greater conversion efficiency of electricity. For the purposes of this map we have assumed **128 PWh** of total primary energy supply, allowing for economic growth and broadly shared prosperity.

### Projection

This map uses the Web Mercator projection for its conformality. It avoids the deformation of equal-area projection. The energy landscape squares are therefore to-scale along the equator.

**We have already paved over or built structures on 800,000 km² of the earth** (the area of the pink square).

The same 800,000 km² area is also shown on the world map at matching scale.

**Using 276,266 km² of land and 16,881 km² of ocean we can power the regenerative global economy of the 21st century using only wind, water, and solar.**

Total energy landscapes and energy oceanscapes comprise 1,392,599 km² and 487,892 km² respectively.

*Remember: land use for solar and wind can often be shared with agriculture or other productive uses. Solar panels can also be sited on reservoirs or rooftops where they don't require any land.*

**For more information about this graphic along with methodology, references, and documentation visit:**

https://landartgenerator.org/blagi/archives/77565

LAND ART GENERATOR
RENEWABLE ENERGY CAN BE BEAUTIFUL

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Build Back Solar will close the door on the doom and gloom of climate change and show that renewable energy can be beautiful, powerful, and equitable.