BUILDINGENERGY BOSTON

Global Passive House: Extreme Climates and Cultural Challenges

Christina Aßmann (Passive to Positive)
Ilka Cassidy (Holzraum System)
Sayo Okada (Studio G)
Sangeetha Sambandam (WRT Design)

Curated by Danny Veerkamp (Woodhull)

Northeast Sustainable Energy Association (NESEA) | March 19, 2024

Christina Aßmann
(Panelist)

Christina Aßmann, NCARB, LEED AP BD+C, WELL AP, Fitwel Ambassador, CPHC
Passive House Consultant
Reloop Architecture,

Ilka Cassidy
(Panelist)

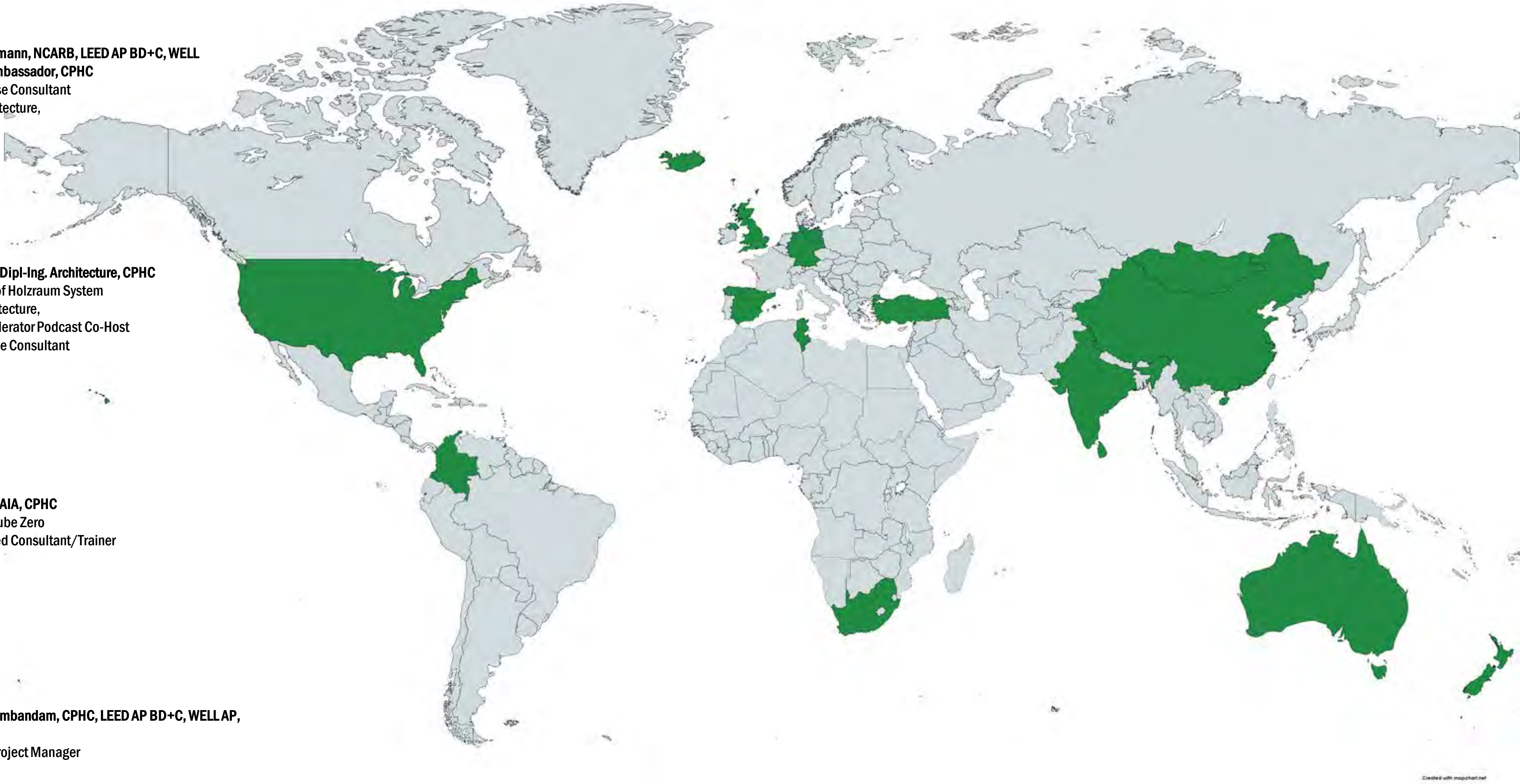
Ilka Cassidy, Dipl-Ing. Architecture, CPHC
Co-Founder of Holzraum System
and C2 Architecture,
Passive Accelerator Podcast Co-Host
Passive House Consultant

Sayo Okada
(Panelist)

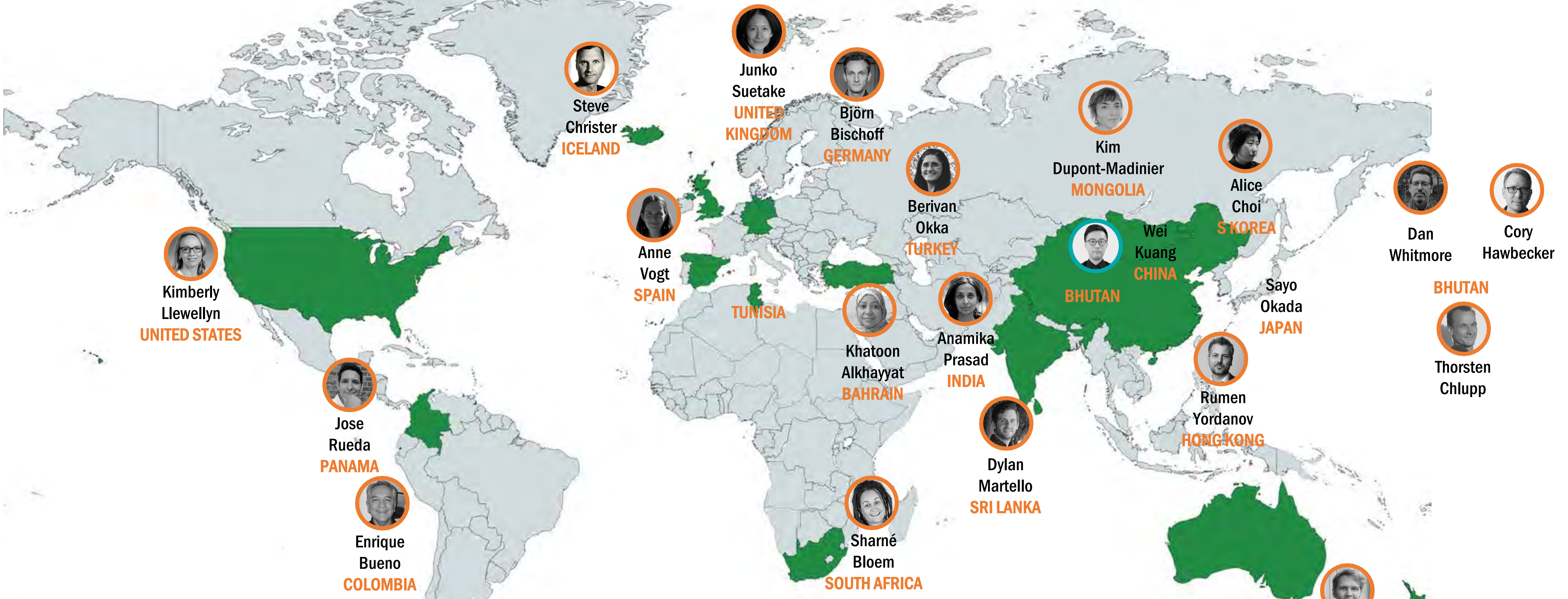
Sayo Okada, AIA, CPHC
Founder of Cube Zero
Phius Certified Consultant/Trainer

Sangeetha Sambandam
(Panelist)

Sangeetha Sambandam, CPHC, LEED AP BD+C, WELL AP, LFA
Associate – Project Manager
WRT, LLC



Northeast Sustainable Energy Association (NESEA)



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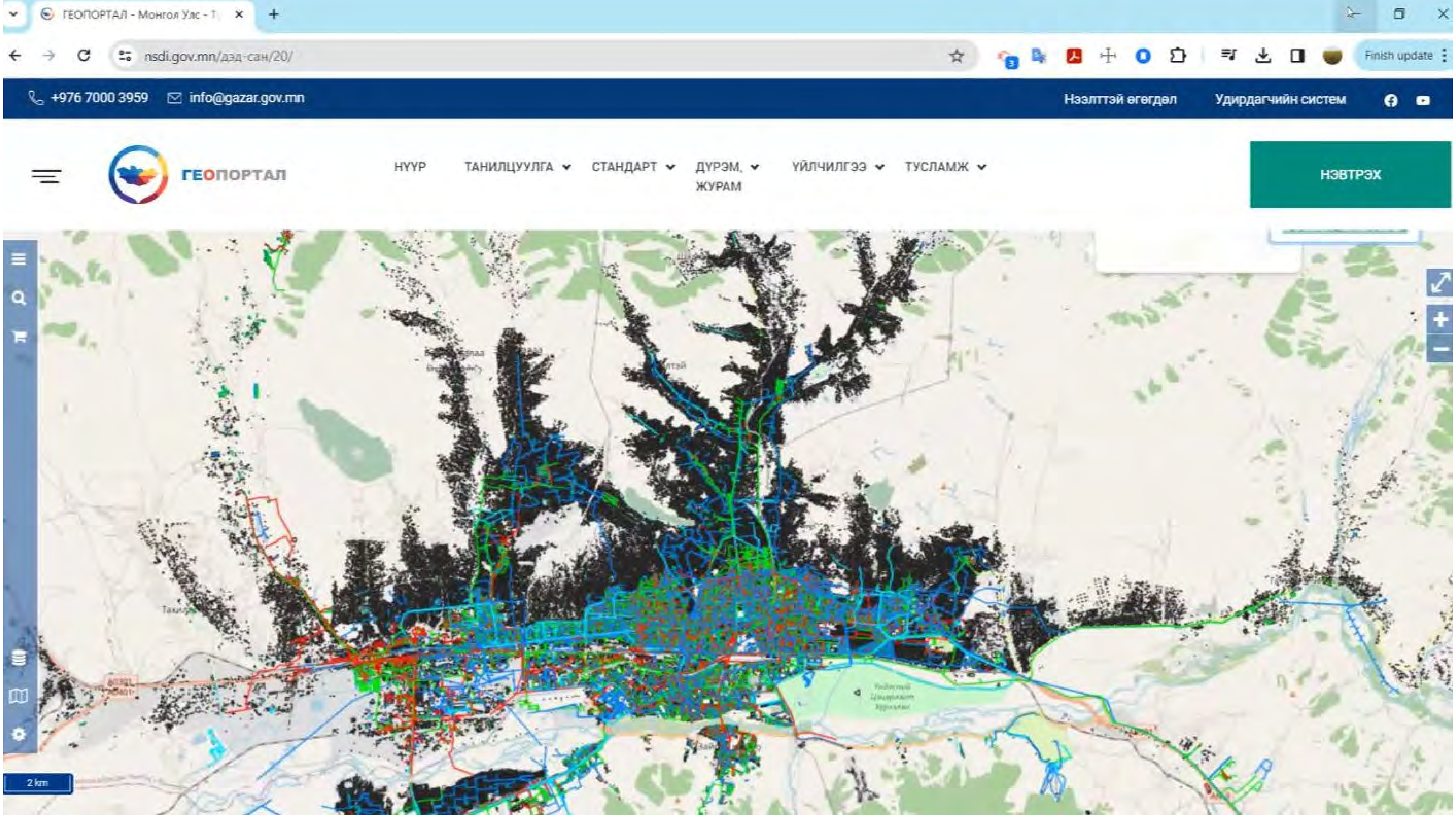
Passive Houses in the Middle Ages - Traditional turf houses in Iceland

First PHI Certified Hospital in Frankfurt, Germany

Mongolia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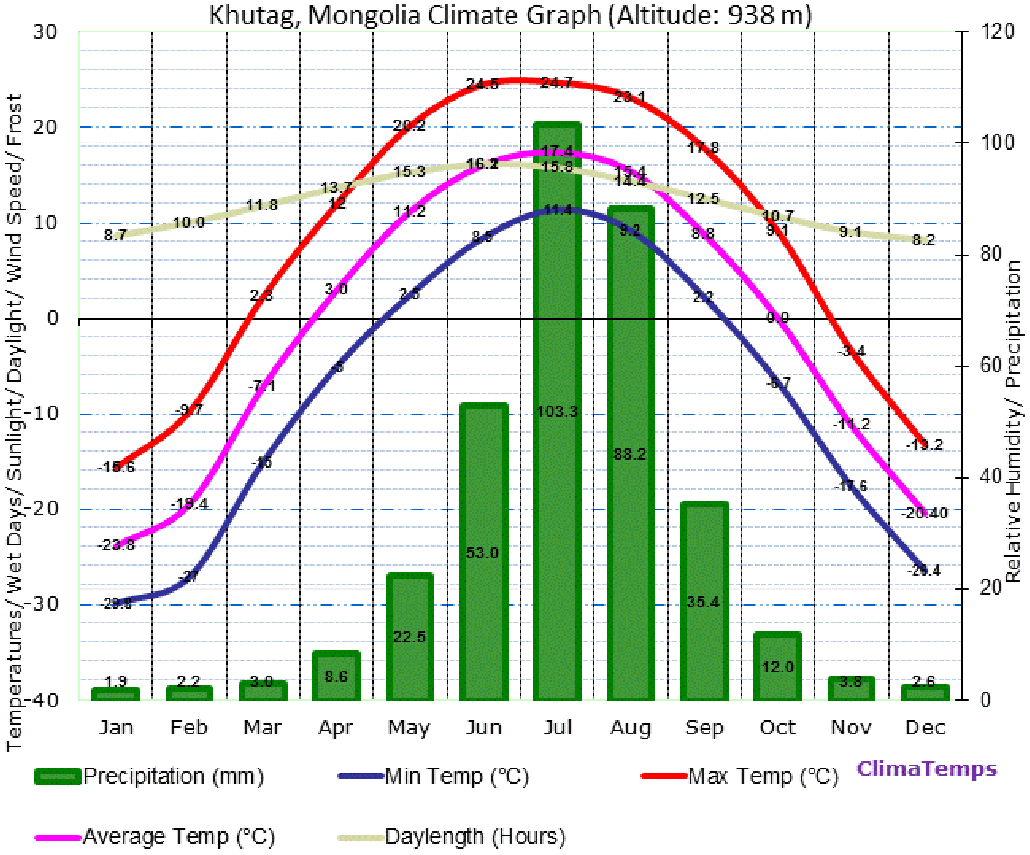
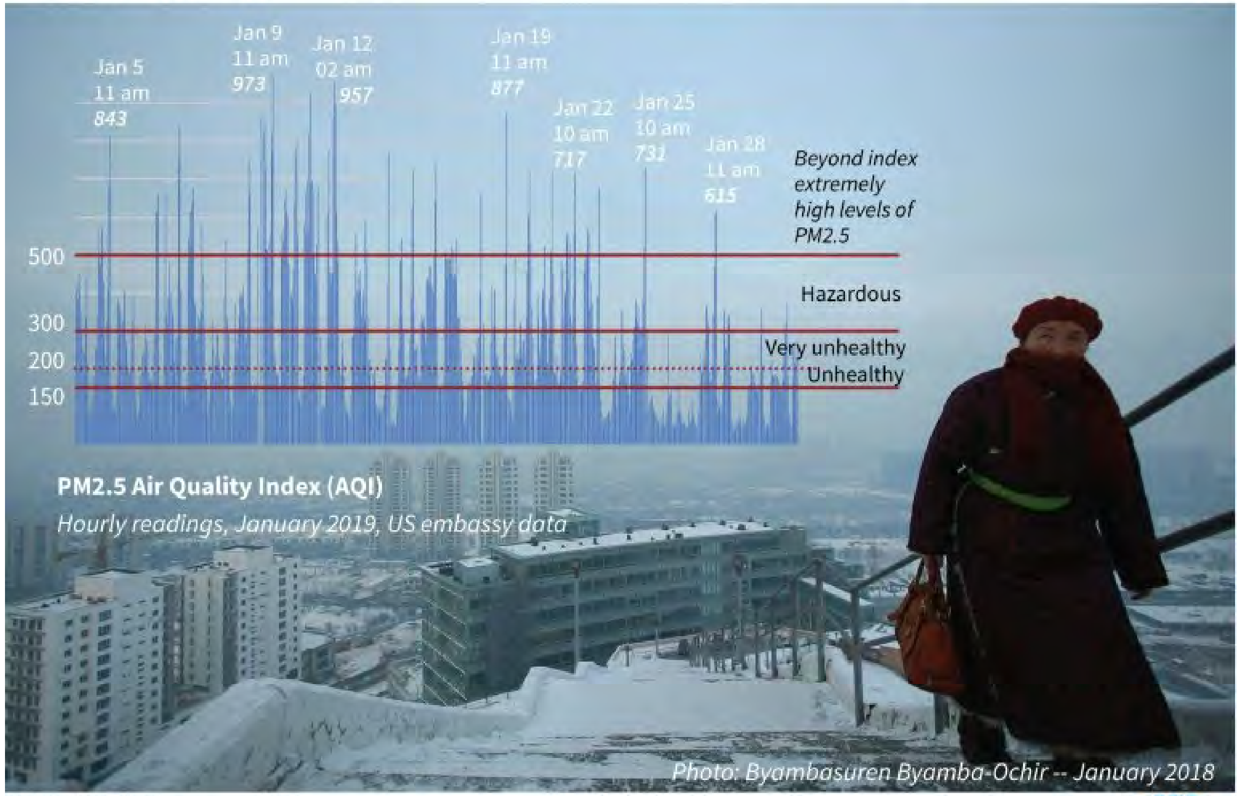
Mongolia

Mongolia



Ulaanbaatar air pollution

The Mongolian capital is one of the world's most polluted cities, regularly exceeding WHO recommendations for air quality readings



Source : US embassy

© AFP

Goldfish house project

Background

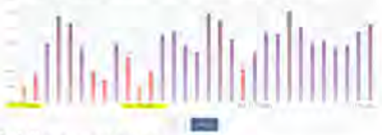
Air pollution caused by fuel burning stoves for heating has been the main source of critical health issues in Ulaanbaatar, Mongolia.

The city experiences an annual average temperature of −1.3°C and has short, warm summers while winters are bitterly cold and dry.

Fig 1 Typical day in ger area in Ulaanbaatar

Temperatures in January are as low as −40°C. Although the government started implementing a raw coal ban in the city to reduce air pollution in 2019, the PM2.5 level still exceeds 300 ppm, which led the Air Quality Index to rank worst in the world.

Fig 2 Historic PM2.5 graph at the location: Songinokhairkhan, Ulaanbaatar, Mongolia



Public awareness

Most people think they must burn fuel to survive the coldest winters. Therefore, people agree to change stoves and improve coal quality, even though the air quality remains worsening by doing so.

Mongolian Passive House Institute is working on showcasing the passive house, which requires almost no heating during winter, to improve public awareness. However, first, we needed more public attention to change people's minds drastically.

Energy efficiency can solve the air pollution issue, even in the coldest capital city in the world! Could goldfish tell us how?

Design of fish house

Before taking any action, research and experiments have been conducted to ensure the goldfish are not in danger during the demonstration. We simulated and tested thoroughly before putting goldfish in the mockup.

The design of the house followed the basic principles of the passive house. In addition, a thermal shutter has been applied to the window. In order to reduce heat loss, the window also functioned as door for maintenance; the wooden frame, as shown below picture, was constructed first and filled with shredded cardboard insulation(cellulose).

The fish tank of 50L acts as a thermal mass absorbing the solar heat energy. Rooftop solar panels of 200W can provide enough power to run air pumps, LED lights and measuring devices inside.

Fig 3 The goldfish house design sketch and during the construction process on-going

Calculations

The thickness of cellulose insulation was 300mm for the roof, walls, and floor, and an additional 50mm XPS was placed on the internal surface. Thermal shutter made out of 50mm XPS. Triple pane low-E glazing U-installed=1.24 W/m^2K, G value= 0.45, Solar irradiation=3000Wh/m^2/day, internal Ti=18°C, Ambient Tn=-25°C(15h/24h night) Td=-11°C (9h/24h day). Combined separate calculations on night and day.

Fig 4 The energy balance scheme of the Goldfish house project

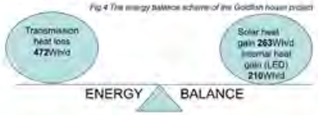
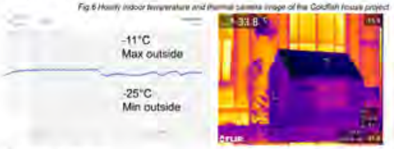


Fig 5 Showcasing the Goldfish house project to the public in front of the Ulaanbaatar central post office

Result

This experiment conducted from 21Jan -1 Feb 2022 Outdoor temperature was -25°C at night and -11°C during day, while internal temperature was stable between 15-20°C throughout 24h measurement, good correlation with the calculation.

Fig 6 Hourly indoor temperature and thermal camera image of the Goldfish house project



Conclusion

Broadcast TV and social media covered this activity during the experiment. As a result, goldfish are healthy and alive, still performing the showcase on Ulaanbaatar streets to raise energy efficiency awareness to fight against air pollution.

Because it is covered very well on social media, many people are now considering insulating their homes and offices. The passive house movement has spread widely since then; workshops and training courses are regularly held to spread knowledge.

It showed the public that we could immediately remove coal-burning stoves after properly retrofitting our homes. Solar power can be the only source of energy to provide comfortable living conditions without the need to burn fossil fuels is the key take out of this project, and it achieved this goal.

Reference
1. Activity
2.
3.Mood show

Ganbaa Nyamaa[1], Amarbayar Adiyabat[2], 1. Mongolian Passive House Institute (NPO), nganbaa@gmail.com, https://www.passive.mn/ 2. National University of Mongolia, SEAS, RE lab., amarbayar@seas.num.edu.mn

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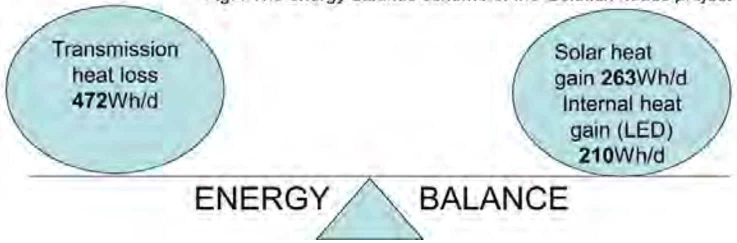

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Fig.6 Hourly indoor temperature and thermal camera image of the Goldfish house project

Mongolia: *Ganbaa Nyamaa & Amarbayar Adiyabat, Mongolian Passive House Institute*

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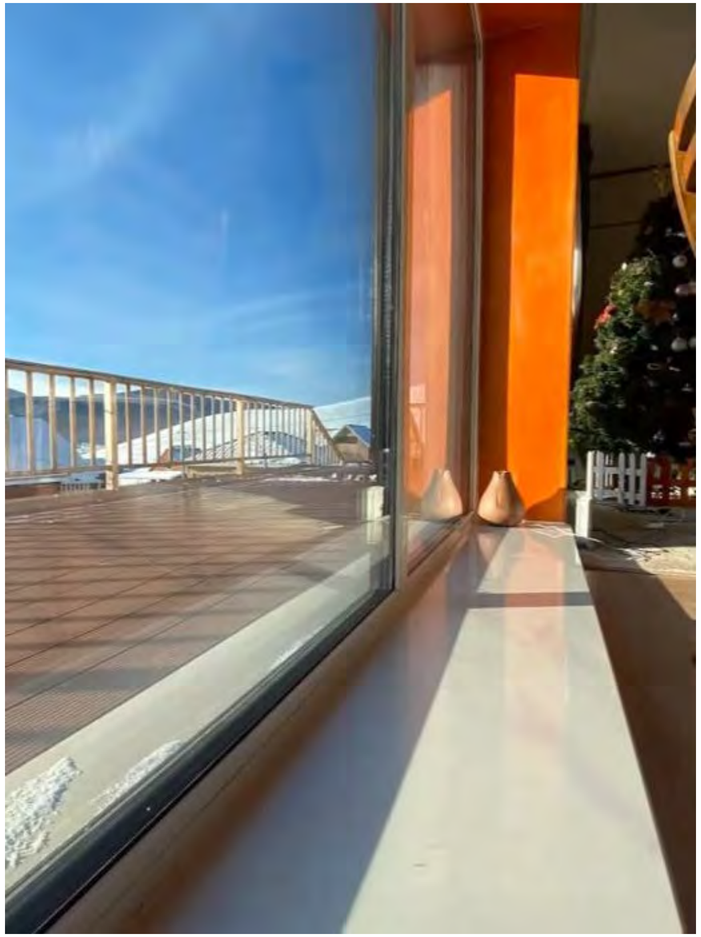


Mongolia: *Ganbaa Nyamaa & Amarbayar Adiyabat, Mongolian Passive House Institute*

Assemblies and PH Data:

- **Walls**: 24” Double stud wall with cellulose – **R 81**
- **Roof:** 27.5” I joist with cellulose – **R 94**
- **Floor:** 18” I joist with cellulose, 2” XPS, on top 10 cm concrete for thermal mass – **R 70**
- **Windows: U 0.14**, improves to **R 28** with thermal shutters
- **Primary Energy: 70 kWh per sqm/year** (PHI target 60 kWh per sqm/ year)

"In Mongolia, Passive House is easy – It's only cold." (Ganbaa)

Takeaways:

- *When it's cold, there is always sun* – Solar gains and PV are very productive
- Thermal mass extremely effective
- Night shutters are successful
- Find solutions for peak conditions without upsizing equipment

- Own standard for Mongolia climate without deviating too much from PHI
- Calculation for pre-heating of ventilation air needs to be adjusted
- Consideration of night shutters
- Own component certification system
- *Season for construction is extremely short* – Local certification body needed

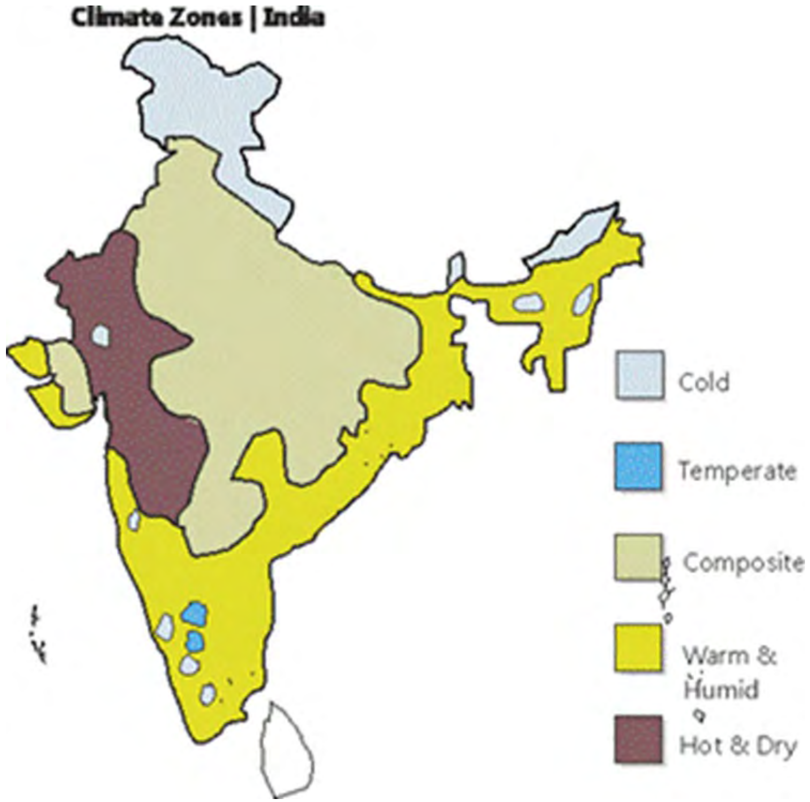
- More education
- More thermal bridge awareness

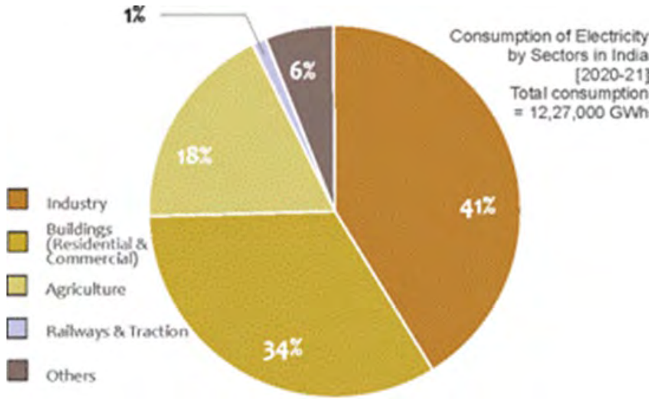
Life in Ulaanbaatar's tent city is hard – but Mongolians won't give up their gers

Though Ulaanbaatar's sprawling informal 'ger district' lacks access to drinking water and sewerage, officials may struggle to coax residents to swap canvas for bricks and mortar

Tens of thousands of rural migrants live in 'ger' tents on the edge of Ulaanbaatar. All photographs: Dan Chung Photograph: Dan Chung

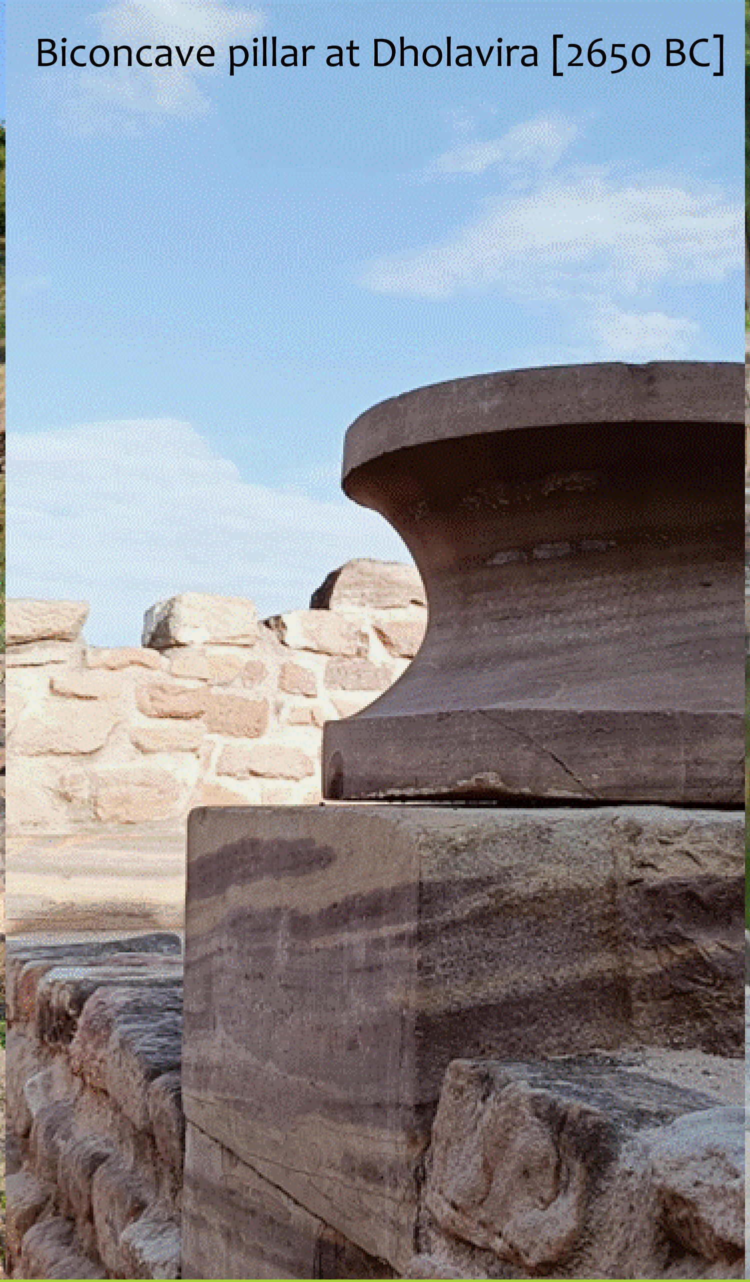
India


Climate Zones | India
Cold
Temperate
Composite
Warm & Humid
Hot & Dry


Consumption of Electricity by Sectors in India [2020-21]
Total consumption = 12,27,000 GWh
1%
6%
18%
41%
34%
Industry
Buildings (Residential & Commercial)
Agriculture
Railways & Traction
Others


nvironmental design solutions


City planning at Indus Valley Civilization


Biconcave pillar at Dholavira [2650 BC]


Water harvesting at Modhera [1026 CE]


Shading device


Courtyard with water body

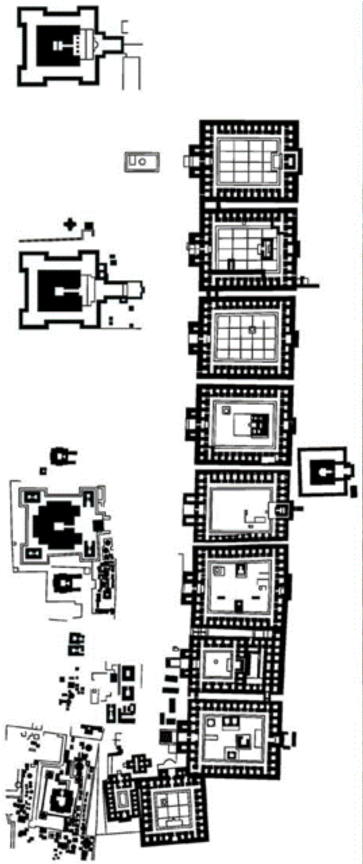

Plastering with mud, lime, and husk

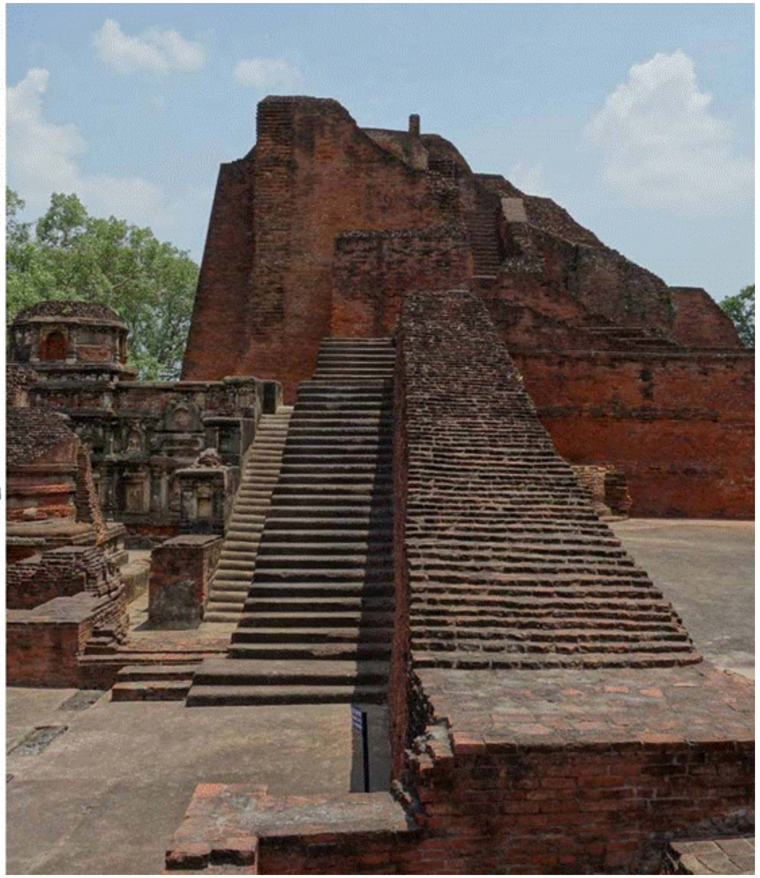
Nalanda was an acclaimed Mahavihara, a large Buddhist monastery and university in the ancient kingdom of Magadha (modern-day Bihar) in India.

Considered by historians to be the **world's very first residential university, and among the greatest centers of learning in the ancient world,** it was located near the city of Rajagriha (now Rajgir).

The University flourished from 427 to 1197 CE and attracted scholars from all over the world.

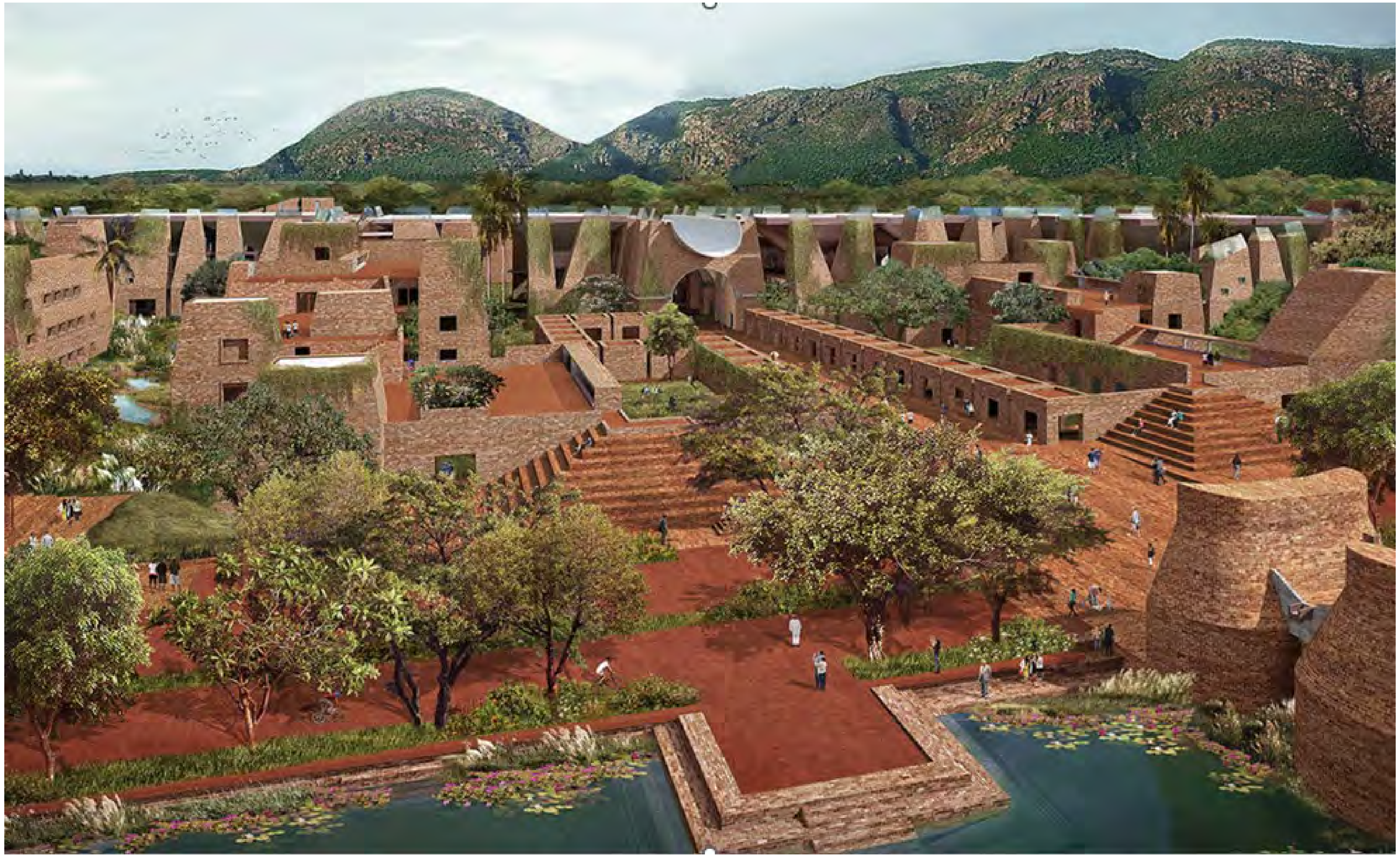
Subjects such as grammar, medicine, logic, philosophy, and mathematics were taught here by renowned scholars.





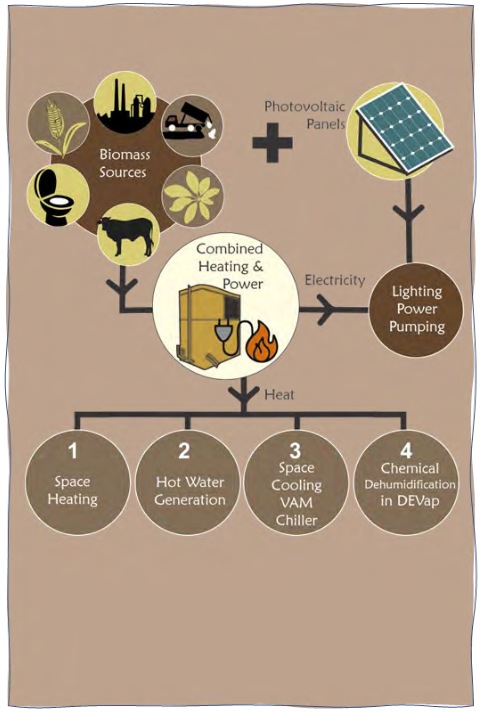
Learnings from the ancient:

- Attention to local climate
- Orientation
- Mass walls for insulation
- Engineered drainage systems
- Passive strategies



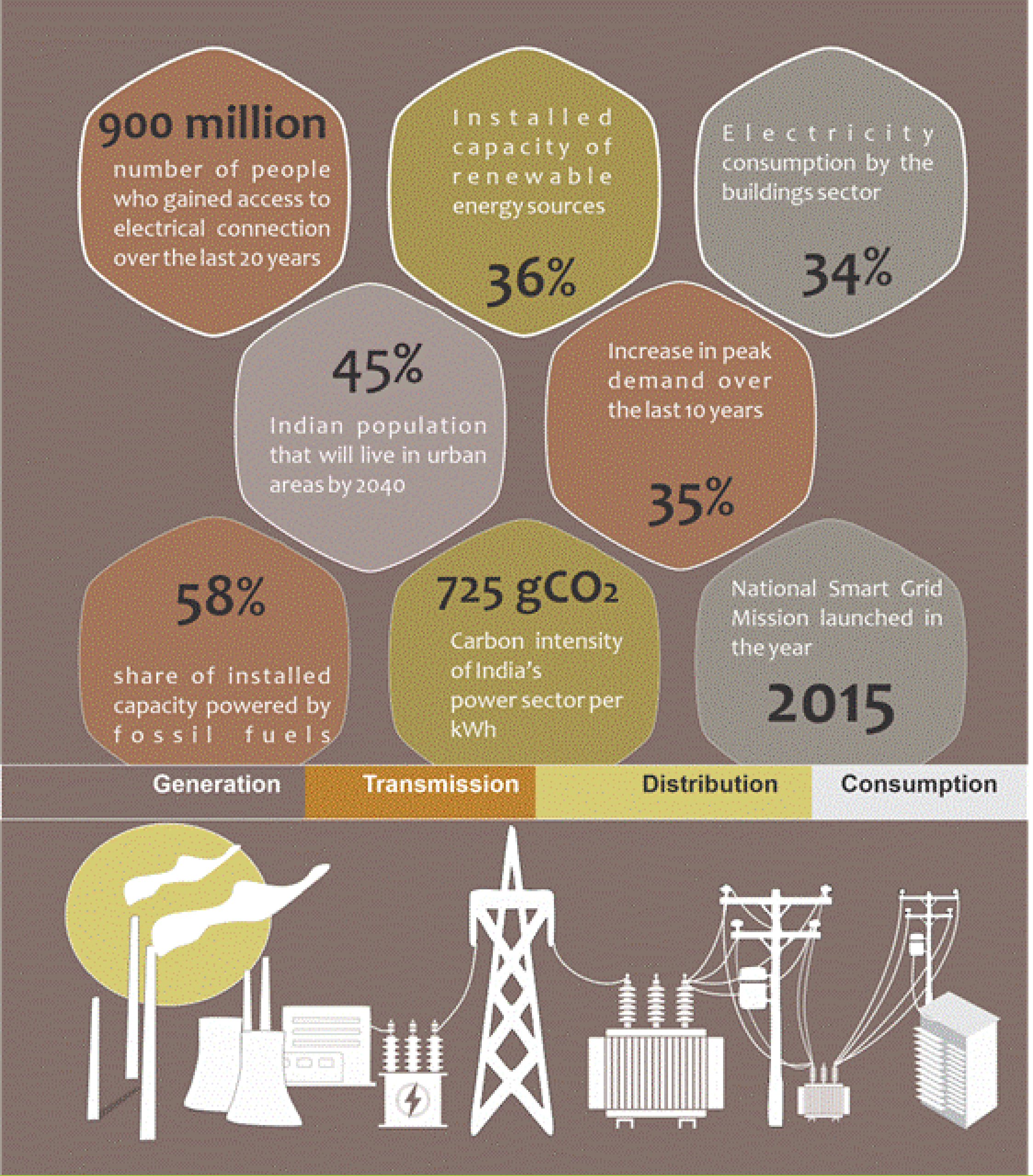
New Campus:

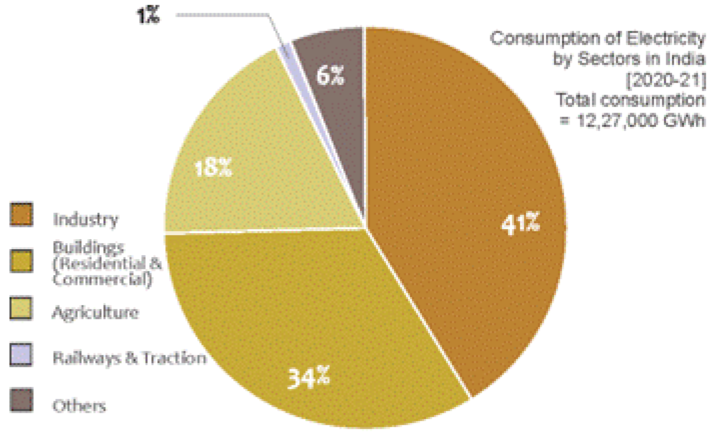
- Passive strategies
- Decarbonization
- Net zero strategy
- Innovative systems
- Biomass
- Resiliency
- Community impact
- Equity
- Culture and local context



Innovative Systems:

- Correct orientation, shading, appropriate envelop and optimized daylighting – reduced heat gain by 20%
- Use of Desiccant Evaporative (DEVAP) technology for cooling/heating of buildings
- Solar Integrated thermal storage technology for HVAC System
- Smart LED lighting, DALI integrated with occupancy sensor
- Use of Compressed Stabilized Earth Blocks (CSEB) blocks instead of common burnt clay bricks
- Use of integrated boxes of masonry to achieve seismic stability
- Use of thick cavity walls to increase thermal resistance
- Climate appropriate landscape design to reduce potable water demand
- Biogas operated Combined Heat & Power (CHP) engine
- Solar PV captive power plant
- Cooling as well as cleaning of the air through use of selected native plants
- Cooling strategy – chemical dehumidification, evaporative cooling and air conditioning – reduced cooling load by 20%
- Automated approach - smart grid
- Proposed use of electricity generated by solar PV, biomass (rice husk & algae)


900 million
number of people who gained access to electrical connection over the last 20 years
Installed capacity of renewable energy sources
36%
Electricity consumption by the buildings sector
34%
45%
Indian population that will live in urban areas by 2040
Increase in peak demand over the last 10 years
35%
58%
share of installed capacity powered by fossil fuels
725 gCO2
Carbon intensity of India's power sector per kWh
National Smart Grid Mission launched in the year
2015
Generation
Transmission
Distribution
Consumption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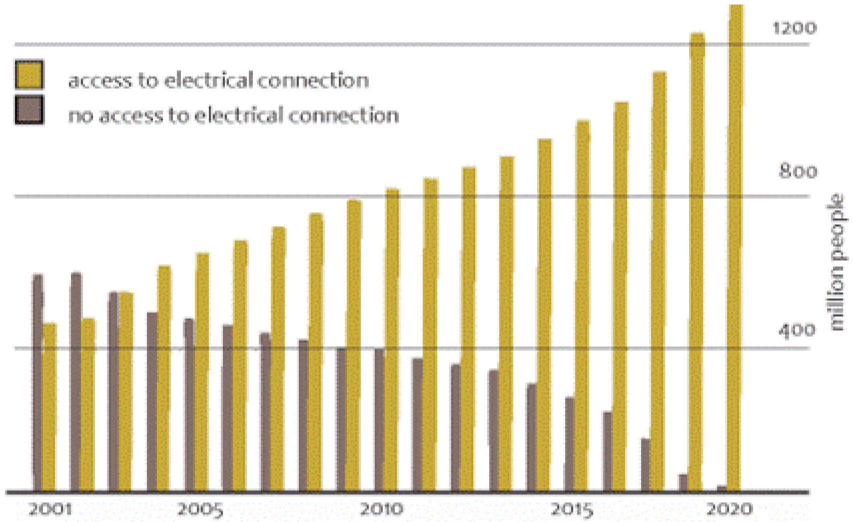
Railways & Traction
Others


access to electrical connection
no access to electrical connection
1200
800
400
million people
2001
2005
2010
2015
2020

Building Envelope

External Wall

- Poured Earth + Insulation
- U-Value 0.22 W/m2.K

Roof

- Ribbed Slab + Insulation
- U-Value 0.20 $W/m^2.K$

Fenestrations

- WWR < 40%
- VLT 0.35
- U factor 2.20 $W/m^2.K$
- SHGC 0.25

Shading

- Light Shelf
- Operable External Louvers

Interior & Exterior Lighting

Useful Daylighting Illuminance

- Over 60% of regularly occupied spaces, have
- 100 lux-2000 lux for 90% of the daylit time,

Interior Lighting & Controls

- LED lighting fixtures
- LPD 6.3 W/m^2
- Occupancy Sensors
- Daylighting Controls

Exterior Lighting & Controls

- LED lighting fixtures
- Astronomical time switch
- LPD 0.25 W/m^2

Mechanical Systems (HVAC)

Total System Efficiency

Maximum Threshold – 0.20 (kW/kWr)

Ventilation

- Treated Fresh Air Units
- Demand control ventilation

Controls

- Temperature controls
- RH controls
- Occupancy controls
- Variable Frequency Drive (VFD)

Plug and Process Loads

- Strategize reduction of workstation loads
- Advanced power strips
- BEE Star Certified Appliances

Renewable Energy Systems

- Maximize SPV installation
- Meet operational energy requirements
- Additional solar energy used towards offsetting Embodied Carbon

Build Light

Optimized structural design and loading

Reduction in the use of high embodied energy materials (concrete and steel)

Ribbed slab roofing systems

High weight-bearing capacity, light construction, and ability to cover large spans

Integration of radiant cooling coils – larger exposed surface area

Build Low Carbon

Material selection and optimized structural engineering design solutions to reduce overall embodied energy of the structure.

Poured earth exterior walls and some internal partition walls

Air-dried sawn timber (door/window frames & Internal partitions)

Ribbed slabs

Bamboo/Wood based external movable louvers

Use of extreme low carbon cement

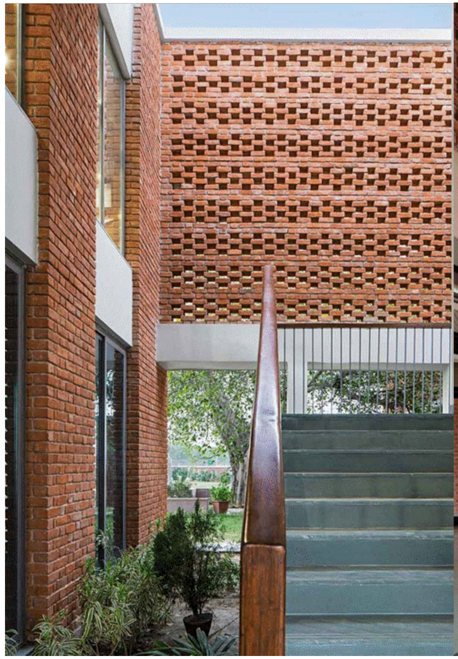
Electric Arc Furnace (EAF) Steel (Rebar)

Build Wise

Evaluation of the embodied energy of materials used in business-as-usual (BAU) construction.

Hot spot analysis that led to the prioritizing elimination/reduction of the use of materials with highest embodied energy i.e.. Aluminum, Concrete and Steel

Use of precast elements in the ribbed slab roofing system enable efficiency in design and helps reduce wastage during construction



Passive House Standard:

- Currently not built
- USGBC - 2002 - LEED in India
- Green Buildings - certifications yet limited to around 2% of formal buildings
- Standard needs more awareness

Challenges:

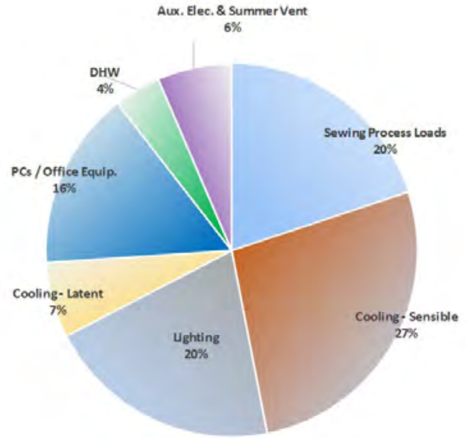
- Cost premiums
- Building methodology
- Continuous rigid insulation products (EIFS available – durability)
- Energy Recovery Ventilators are currently being used in some building typologies (indoor air quality and energy savings); taking it further to meet Passive House standard could be a challenge
- Housing: most climates don't need heating or cooling 7 – 8 months
- Windows opened for ventilation (cultural context)

Opportunities:

- Many cities have a high pollution rate
- Energy Recovery Ventilators – available
- Heat Pump technology - available
- Could be successful in some typologies
  - Factories – due to high energy demand
  - High end market rate/ luxury housing
  - awareness with cost premiums
  - Schools – private schools

Passive House Standard:

- Tropical-warm/humid climate - cooling dominated
- Successful retrofit (PHI Enerphit)
- Clothing factory - with upto 60% energy reduction
- PH construction methodology was a challenge
- Some products like air barriers were Imported
- Ext. continuous insulation - EIFS system locally available
- Energy Recovery Ventilator - imported from India
- Cultural context: Restrooms outside of PH thermal boundary



Client	Star Garment / Komar Brands
Passive House Designer	Jordan Parnass Digital Architecture
Energy Consultant	Steven Winter Associates
Quantity Surveying	475 High Performance Building Supply
Architect	Vinod Jayasingh Architects
Structural Engineering	URO Structural
HVAC Engineering	Chandana Dalugoda Consultants
Mechanical Engineering	K2 Consultants
Cost Consultant	Vform
General Contractor	Tritech Engineering & Civicon Engineering

Japan

Tunisia

Tunisia

Bulla Regia

Archeological Site
1st Century BCO

Tunisia

Bulla Regia

Archeological Site
1st Century BCO

Tunisia

Matmata

Berber Village

Tunisia

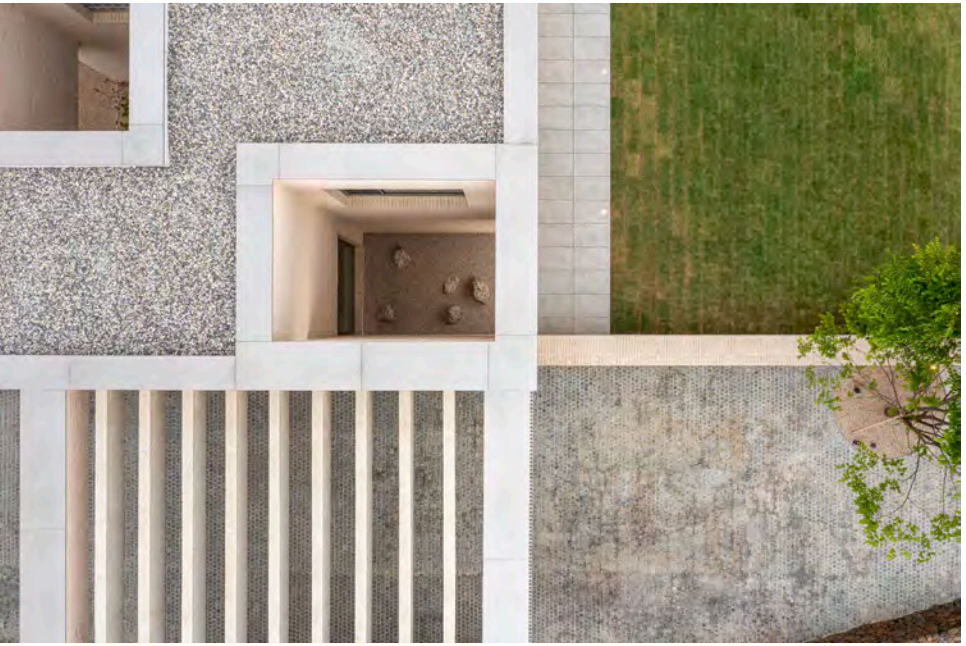
Sidi Bou Saïd

Dar El Annabi

Tunisia

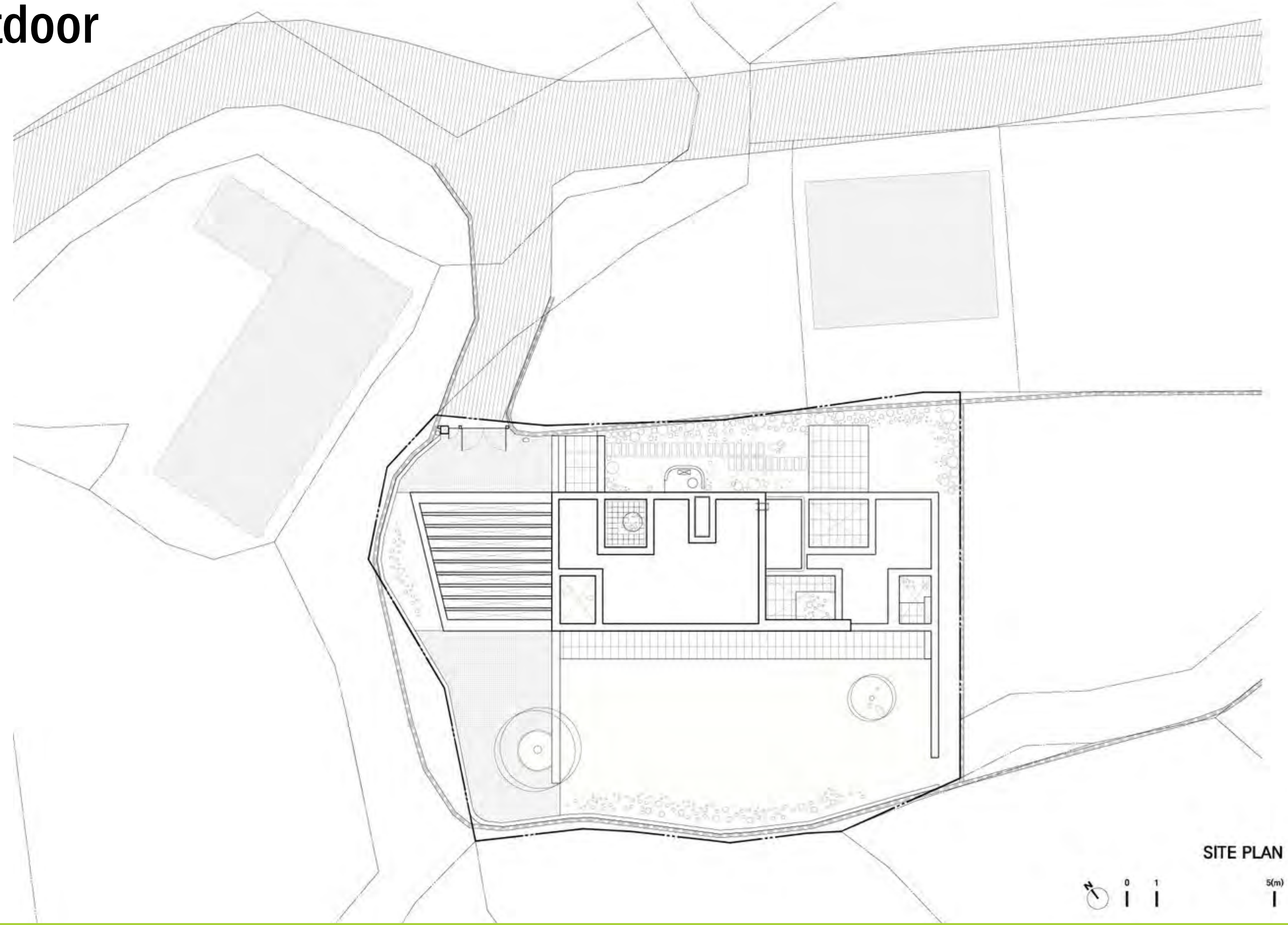
Tunisia

Indoor/Outdoor

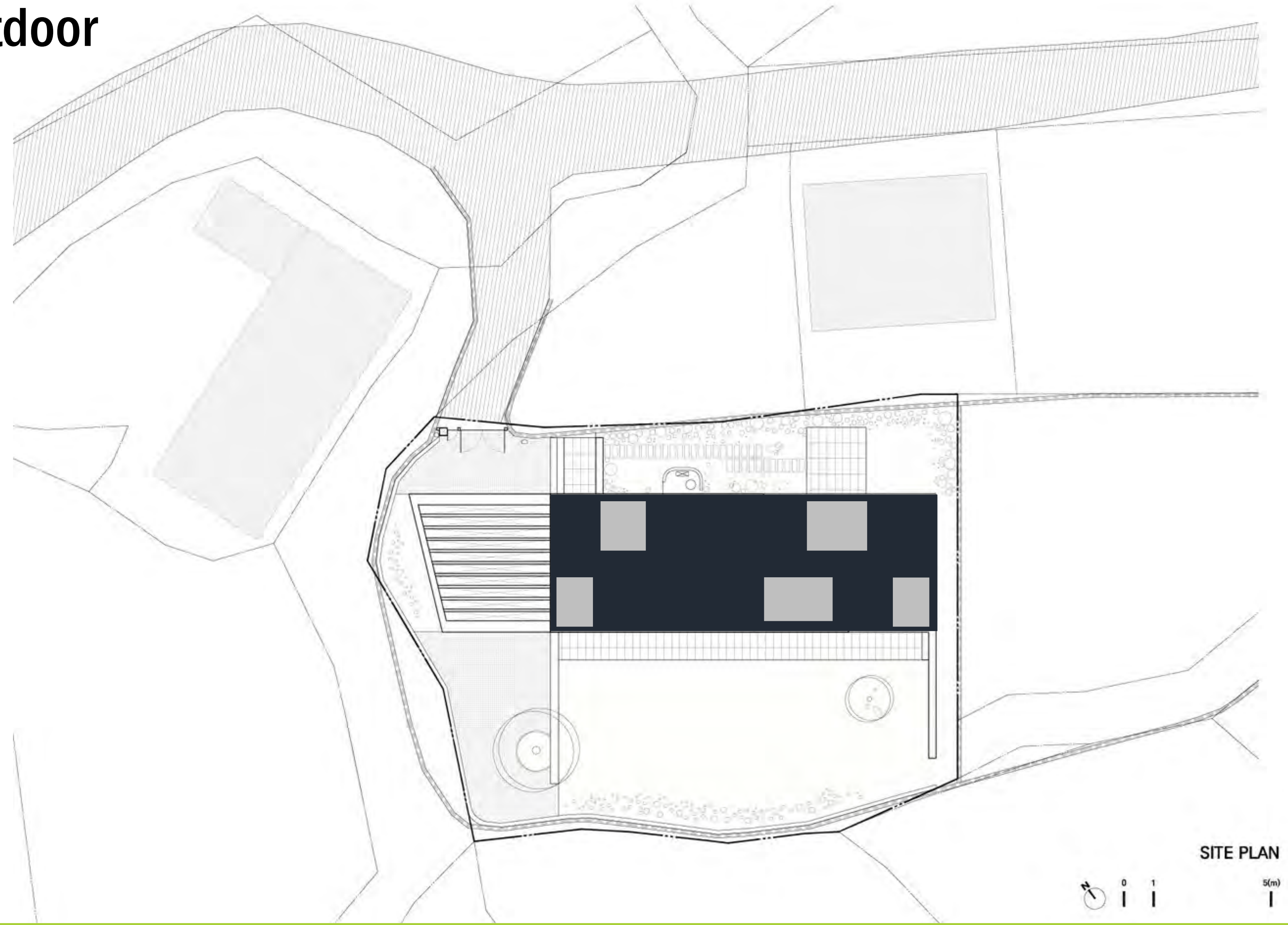


Source: ArchDaily

Indoor/Outdoor



Indoor/Outdoor



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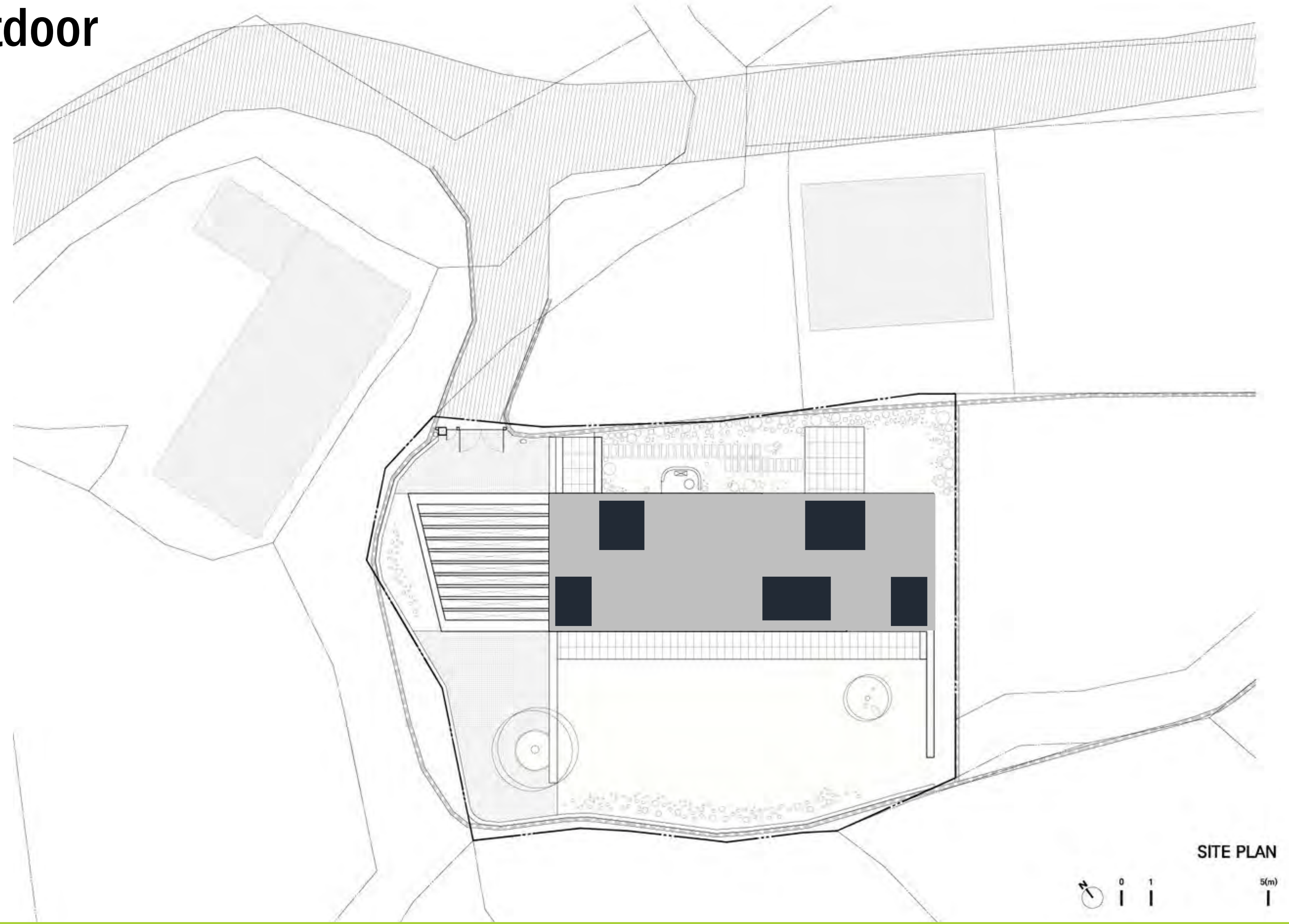

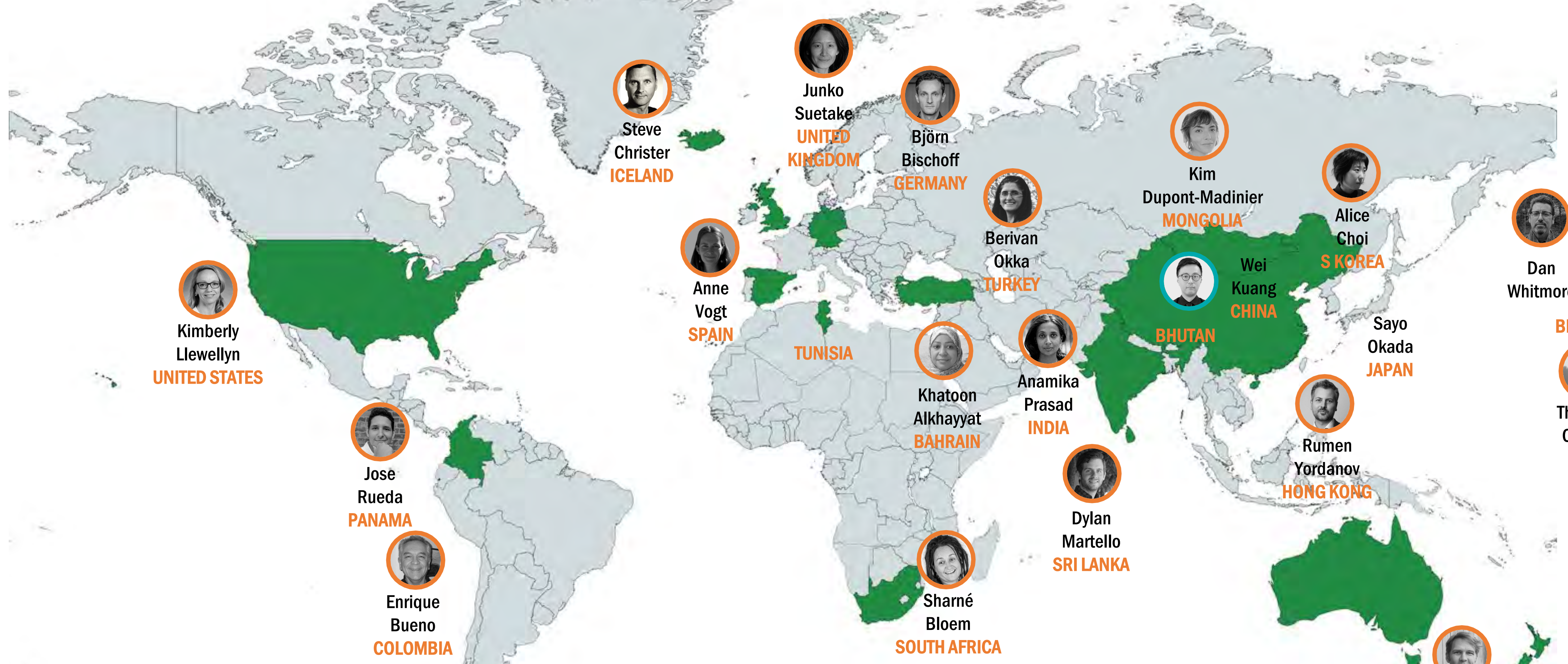

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Associate – Project Manager
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