Solar Access Study Report
970 Franklin Avenue

June, 2024

Thornton Tomasetti, Inc.
120 Broadway
New York, NY 10271

Thornton Tomasetti

EXECUTIVE SUMMARY

Thornton Tomasetti, Inc. has been appointed by The Continuum Company to consult on the project of 970 Franklin Ave.

The report analyzes the impact of the proposed design of 970 Franklin Ave to the greenhouses of Brooklyn Botanic Gardens in terms of the solar access reduction.

This assessment has been organized into 3 sections:

1. Shadow Benchmark: Impact of the reduced direct sun hours

2. Annual Solar Radiation Study: Impact of the reduced incident solar radiation

3. Photosynthetically Active Radiation (PAR) Study: Impact of the reduced PAR for plant growth

Analysis Assumption

Simulation Software:

- Rhinoceros 3D Version 7 (Robert McNeel & Associates)
- ClimateStudio (Solemma LLC)
- Grasshopper (Robert McNeel & Associates)
- Ladybug Tools (Ladybug Tools LLC)

Climate Data:

- USA_NY_New.York-Central.Park.725033_TMY3

Design:

- Rhino model layer "3D-PROPOSED NEW" (New with Bulkhead)

Context:

- Provided by client

Trees:

- Including those immediate adjacent to the greenhouses
- Tree canopy size and density approximated with Google Earth
- Tree leaf growth, shrinkage, and color schedule considered

Analysis Methodology

Section1: Shadow Benchmark

Analysis Context:

- Proposed Design

Analysis Area:

- The surrounding ground level surface of the greenhouses

Analysis Period:

- Seasonal 24-hour periods

Metric:

- Direct sun hours

The first section of this assessment examines the hours when the proposed building casts shadow over the greenhouses in its greatest extent. Shadow simulations are conducted for several point-in-time analyses, at all 24 hours for the summer solstice, fall equinox, and winter solstice. The first section benchmarks the possible radiation reduction hour range for subsequent analyses.

Section 2: Annual Solar Radiation Study

Analysis Context:

- Proposed Design
- Surrounding Trees
- Context buildings

Analysis Area:

- The roof level surfaces of the greenhouses in two groups

Analysis Period:

- Annual all hours
- Annual before 9am

Metric:

- Incident Solar Radiation [kWh/m^2]

The second section of this assessment uses solar radiation on the greenhouse roof areas as the metric to evaluate the potential shading loss in radiation due to the proposed design.

Section 3: Photosynthetically Active Radiation (PAR) Study

Analysis Context:

- Proposed Design
- Surrounding Trees
- Context buildings

Analysis Period:

- Monthly

Analysis Area:

- The roof level surfaces of the greenhouses in two groups

Metric:

- Daily Light Integral (DLI) [MJ/m^2-day]

The last section of this assessment uses Daily Light Integral (DLI) on the greenhouse roof areas as the metric to evaluate the potential shading loss in photosynthetically active radiation (PAR) due to the proposed design.

DLI is typically expressed in mol/m^2-day or MJ/m^2-day. Each plant species has its own optimal DLI range which will influence growth level and life expectancy.

EXECUTIVE SUMMARY

Analysis Findings

Section 1: Shadow Benchmark

North:

- The proposed design casts shadows in winter mornings 8-9am

South:

- The proposed design casts shadows in summer mornings 6-8am and in Spring/Fall mornings 7-9am

The proposed design only adds possible new shadows before 9am, benchmarked for the following sections to evaluate radiation conditions before 9am.

Section 2: Annual Solar Radiation Study

North:

- Radiation before 9am only account for less than 15% annually
- Considering existing trees surrounding the greenhouses, the building reduces 3 kWh/m^2, or 0.3% annual radiation

South:

- Radiation before 9am only account for less than 14% annually
- Considering existing trees surrounding the greenhouses, the building reduces 6 kWh/m^2, or 0.4% annual radiation

The proposed design reduces less than 1% of the annual incident solar radiation reaches on the green houses in average.

Section 3: PAR Study

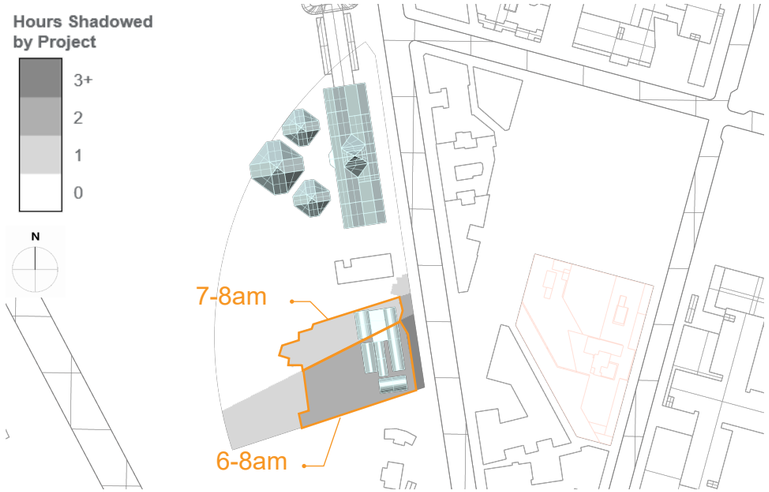
North:

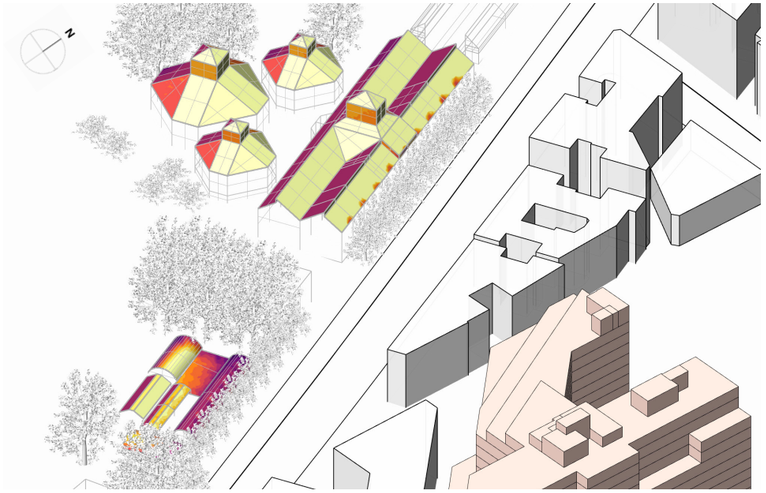
- The proposed design decreases 0.01 MJ/m^2-day, less than 0.1% of the total DLI in July

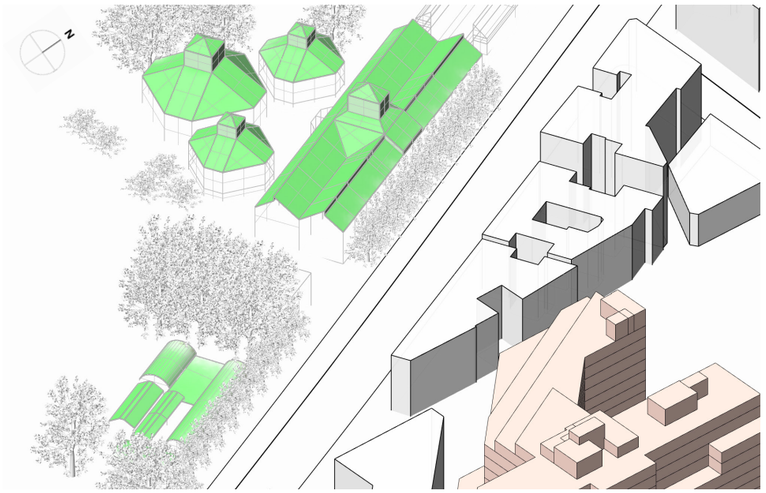
South:

- The proposed design decreases 0.11 MJ/m^2-day, less than 1% of the total DLI in July

The proposed design reduces less than 1% of the DLI in July, and still allows 11-14 MJ/m^2-day to reach the greenhouses, sufficient for most plants requiring high quality DLI.

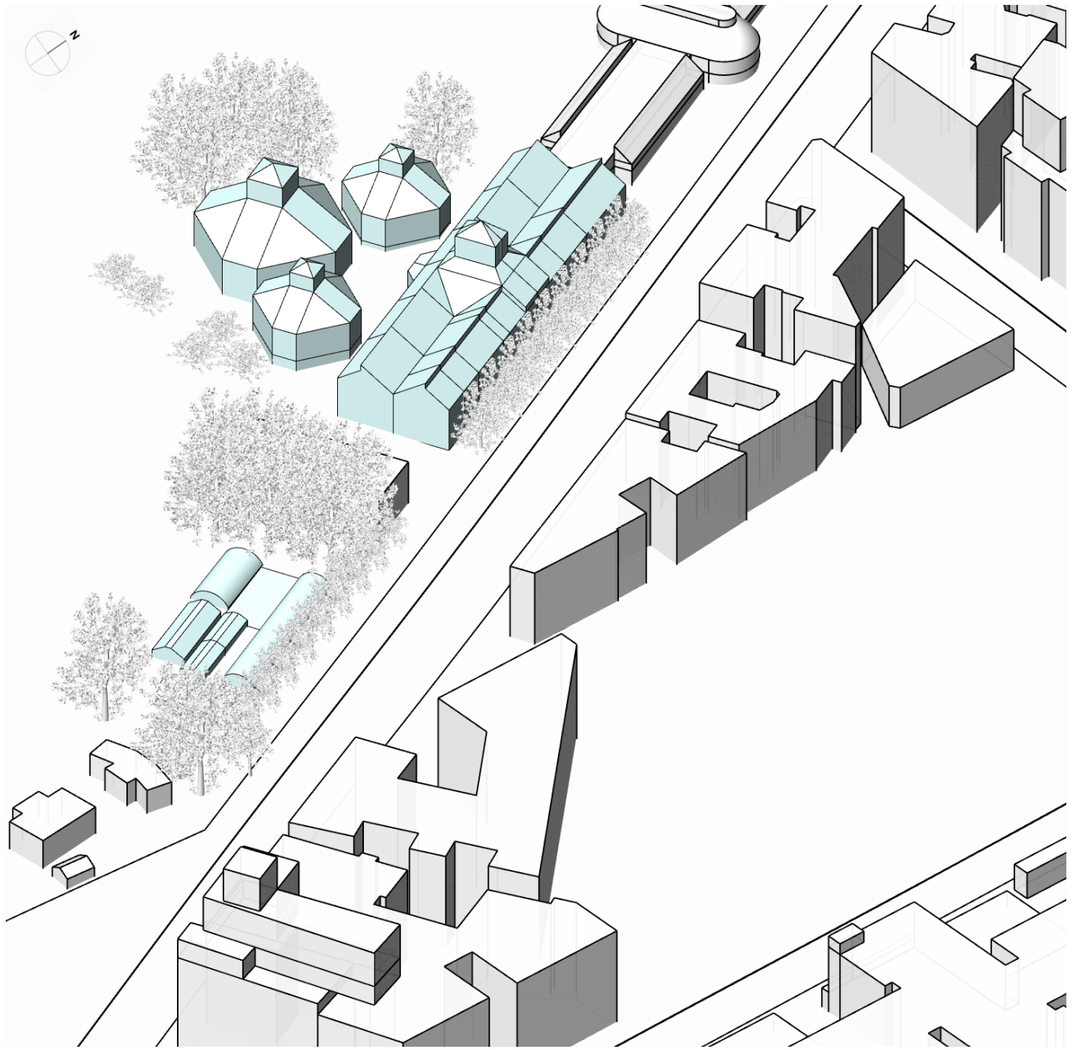




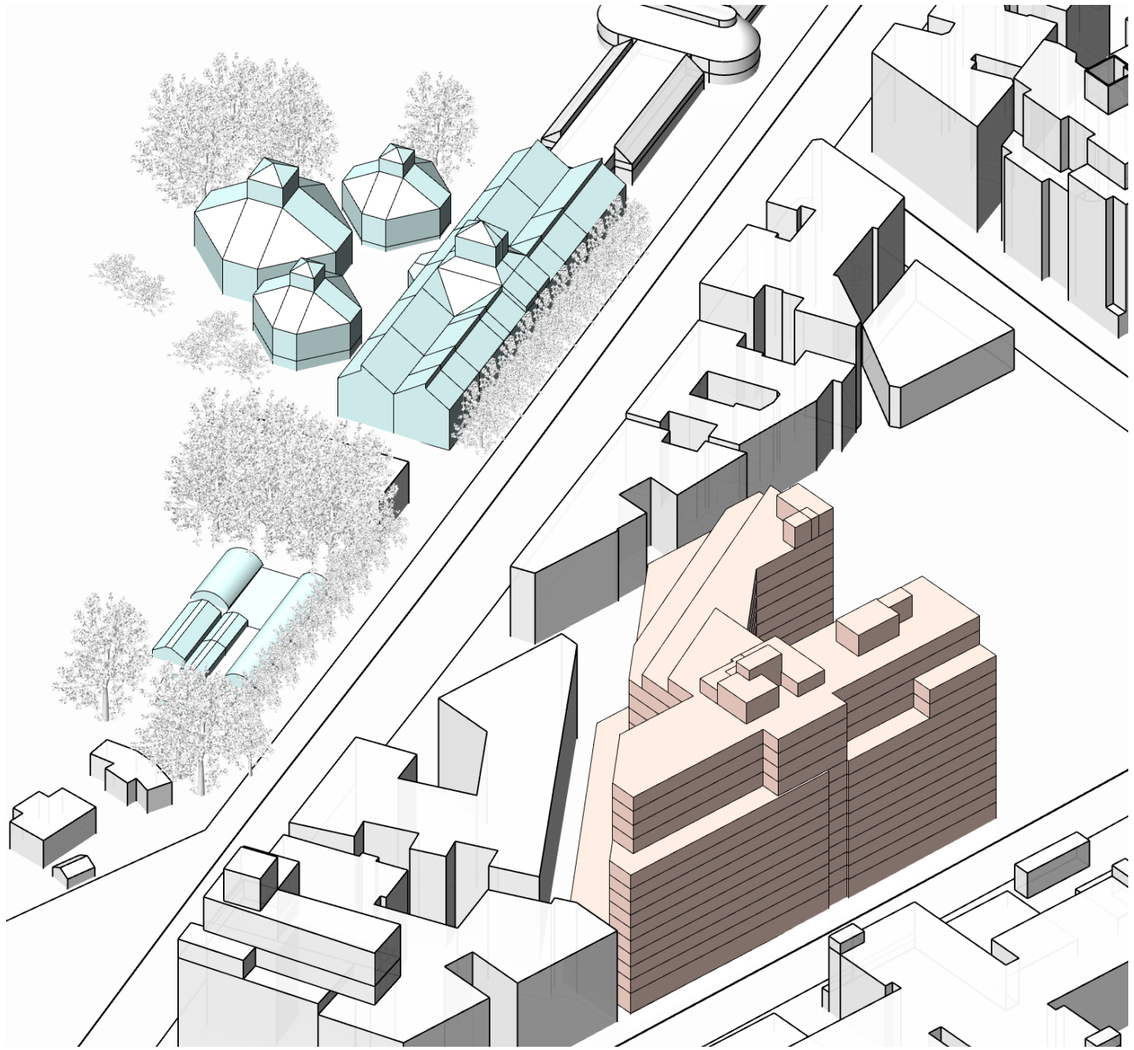


MODEL SET-UP

Existing Condition



Proposed Design



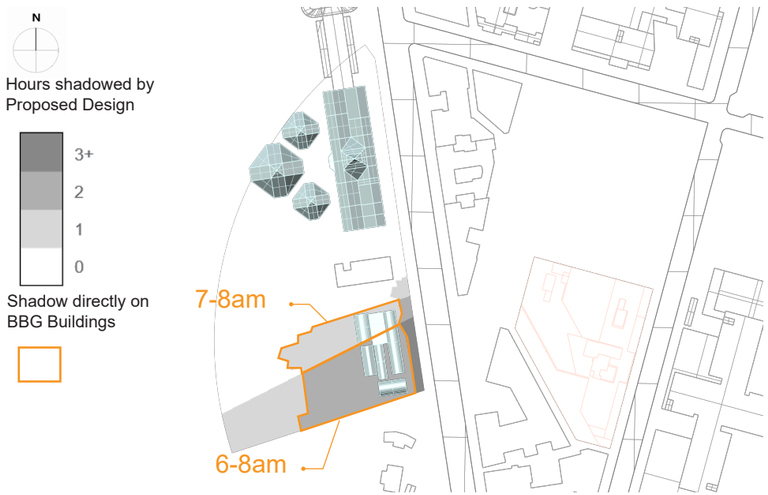
TREE MODEL REFERENCE

Google Satellite Image

SECTION 1: BENCHMARK SHADOW RANGE

Proposed Design

Summer Solstice (DST)



Summer Findings:

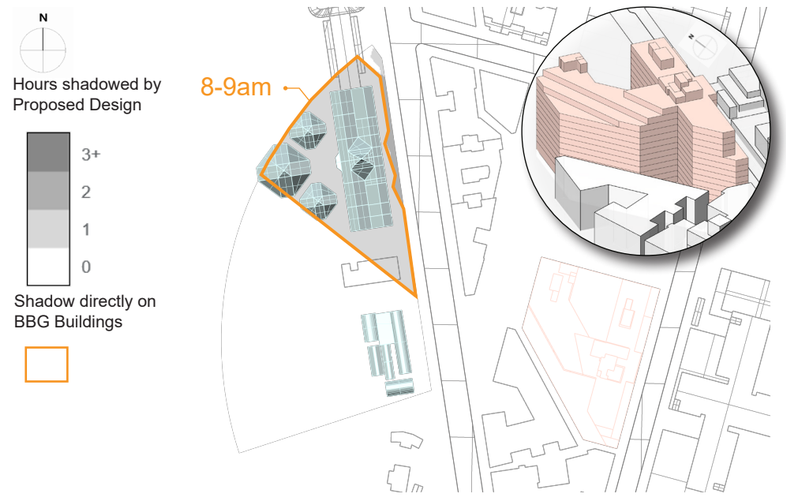
- North:
  The proposed design does not cast any shadow.
- South:
  The proposed design only casts shadows from 6am to 8am.

Spring/Fall Equinox (DST)

Spring/Fall Findings:

- North:
  The proposed design hardly casts any shadow.
- South:
  The proposed design only casts shadows from 7am to 9am.

Winter Solstice (EST)

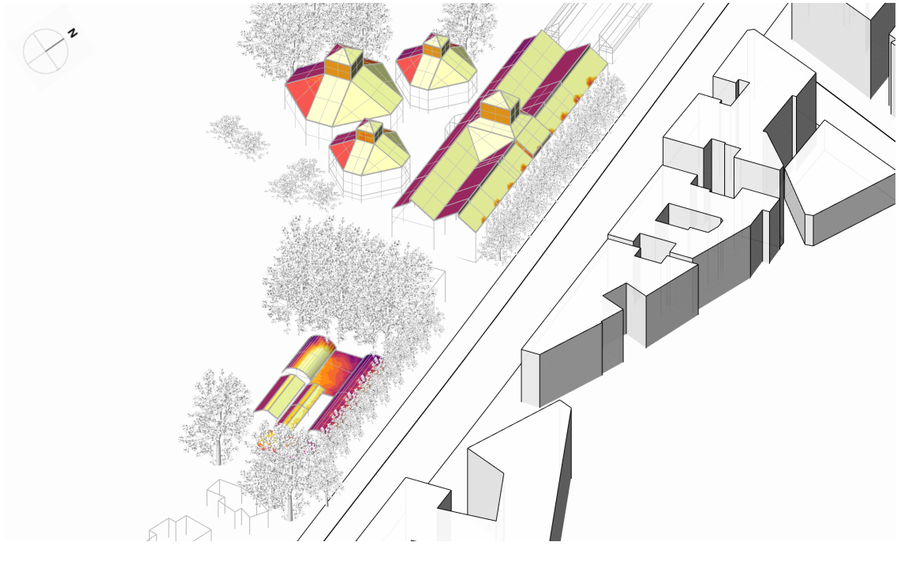


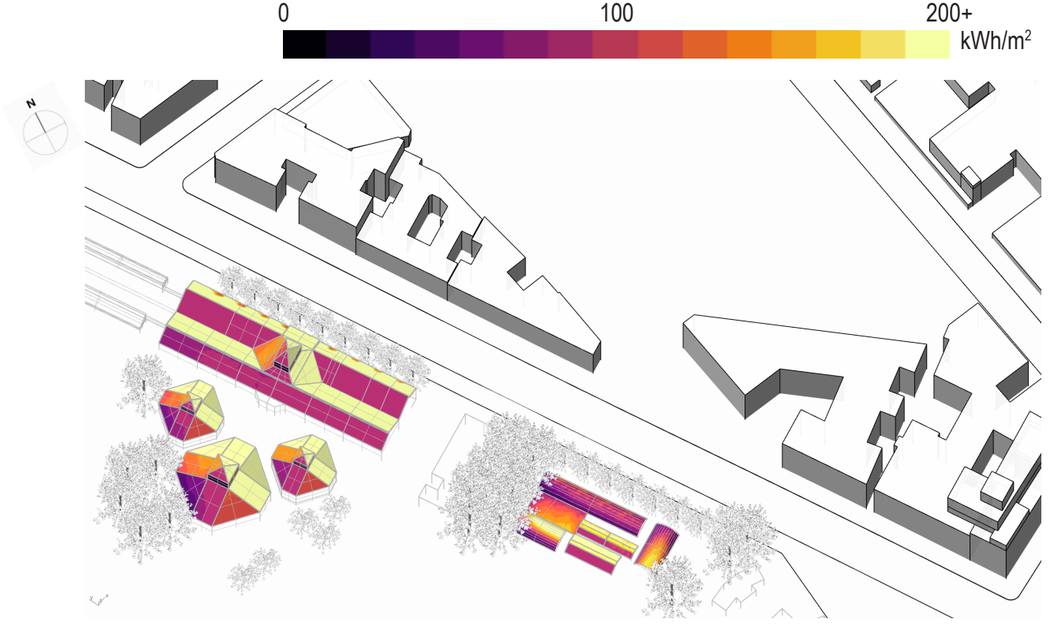
Spring/Fall Findings:

- North:
  The proposed design only casts shadows from 8am to 9am.
- South:
  The proposed design does not cast any shadow.

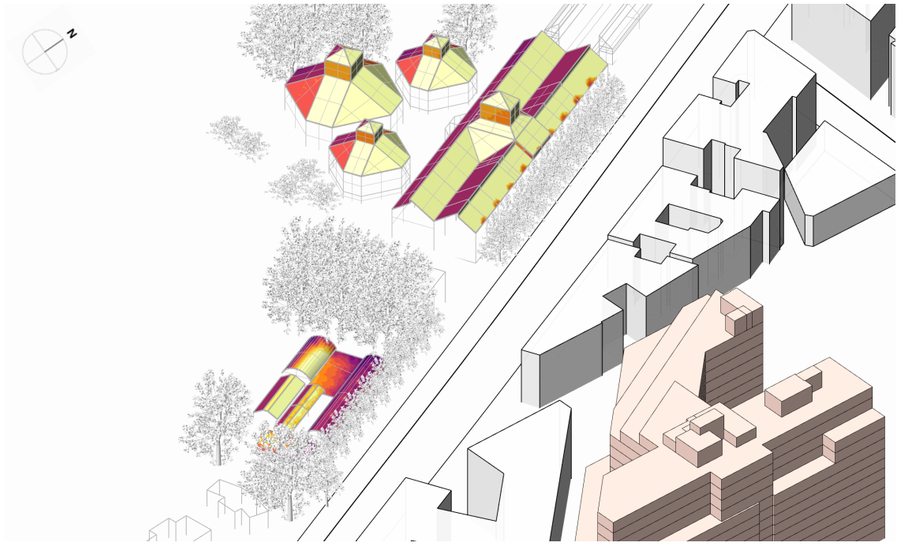
SECTION 2: ANNUAL SOLAR RADIATION STUDY (RADIATION BEFORE 9AM)

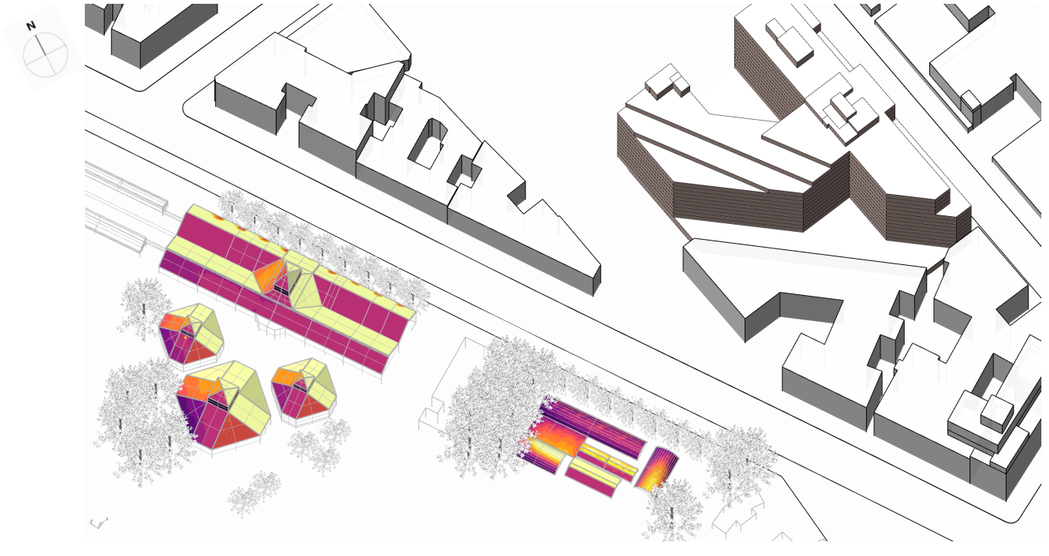
Existing Condition





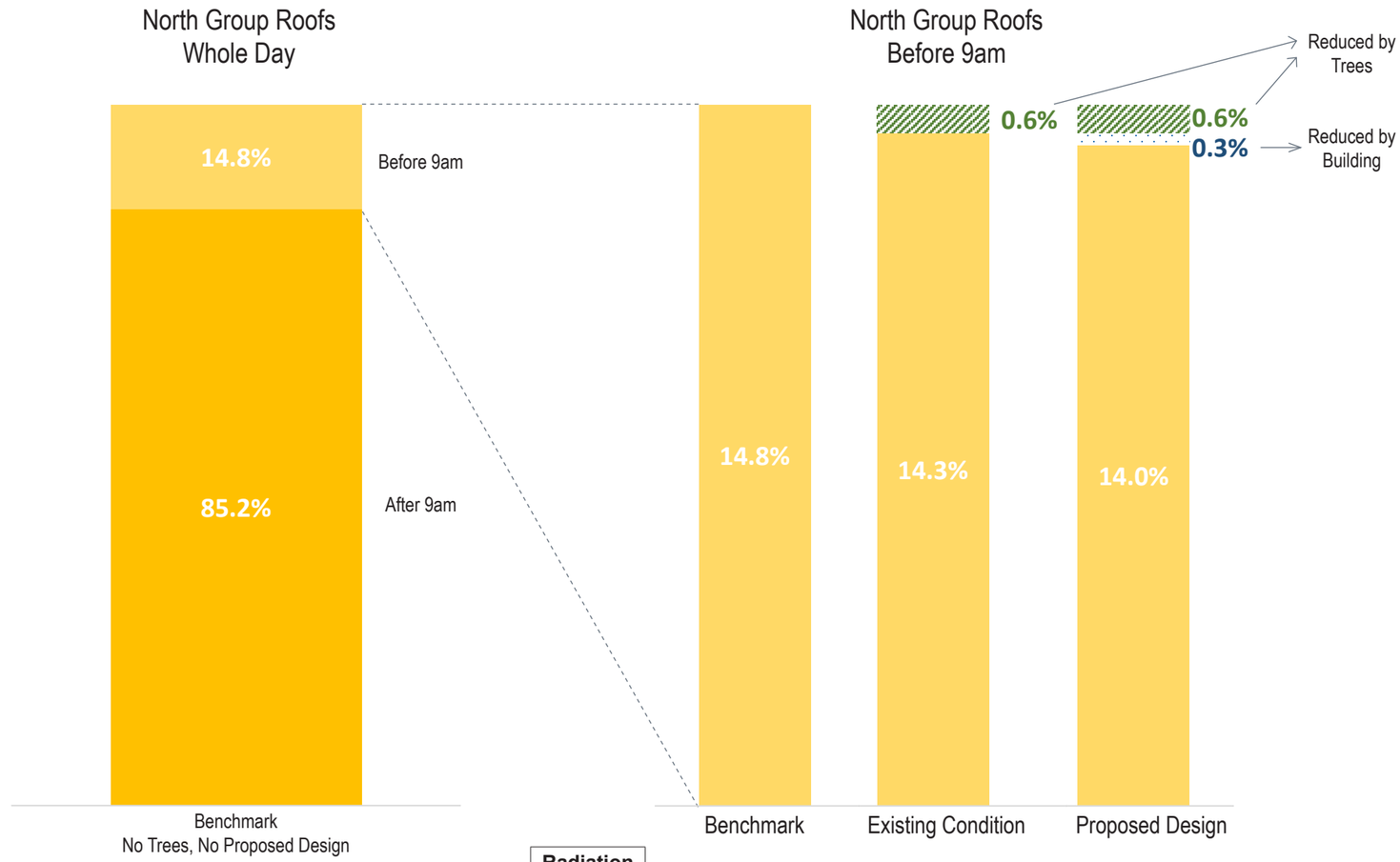
Proposed Design





SECTION 2: ANNUAL SOLAR RADIATION STUDY - NORTH

Annual Incidental Solar Radiation



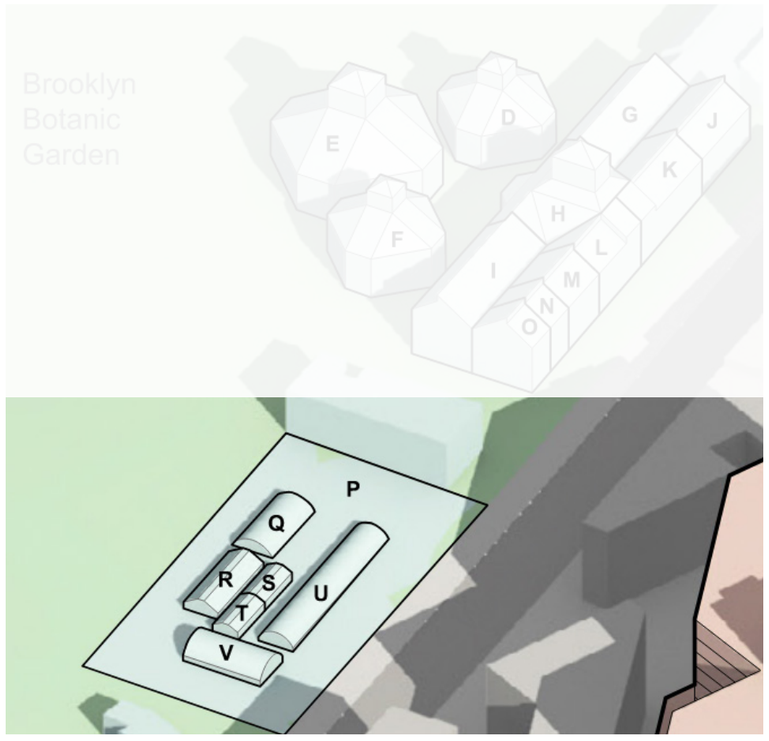
Radiation [kWh/m²]	Benchmark	Existing Condition	Proposed Design
Reduced by Trees	-	(7)	(7)
Reduced by Building	-	-	(3)
Before 9am	181	174	171
After 9am	1,039	1,004	1,004

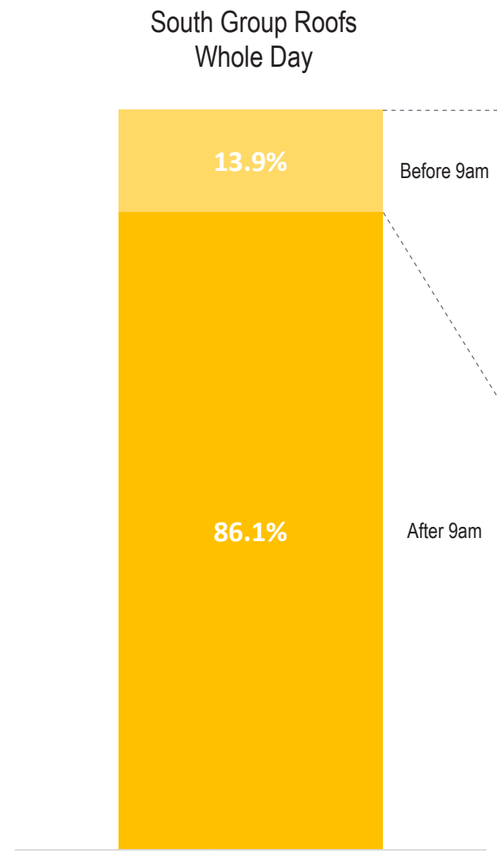
Key Findings:

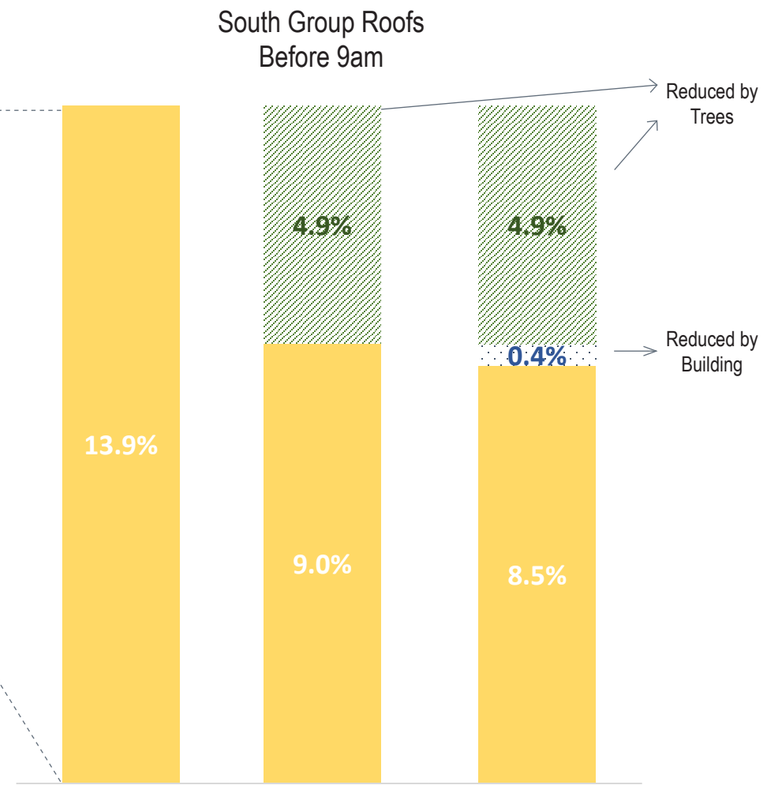
- Radiation before 9am only account for less than 15% annually.
- Considering existing trees surrounding the greenhouses, the building reduces 3 kWh/m², or 0.3% annual radiation.

SECTION 2: ANNUAL SOLAR RADIATION STUDY - SOUTH

Annual Incidental Solar Radiation







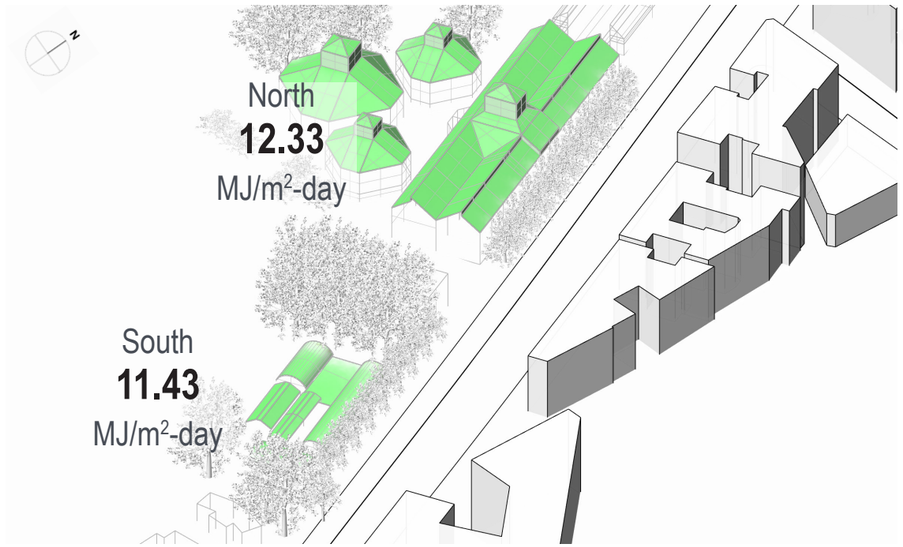
Radiation [kWh/m²]	Benchmark	Existing Condition	Proposed Design
Reduced by Trees	-	(64)	(64)
Reduced by Building	-	-	(6)
Before 9am	182	118	112
After 9am	1,130	958	958

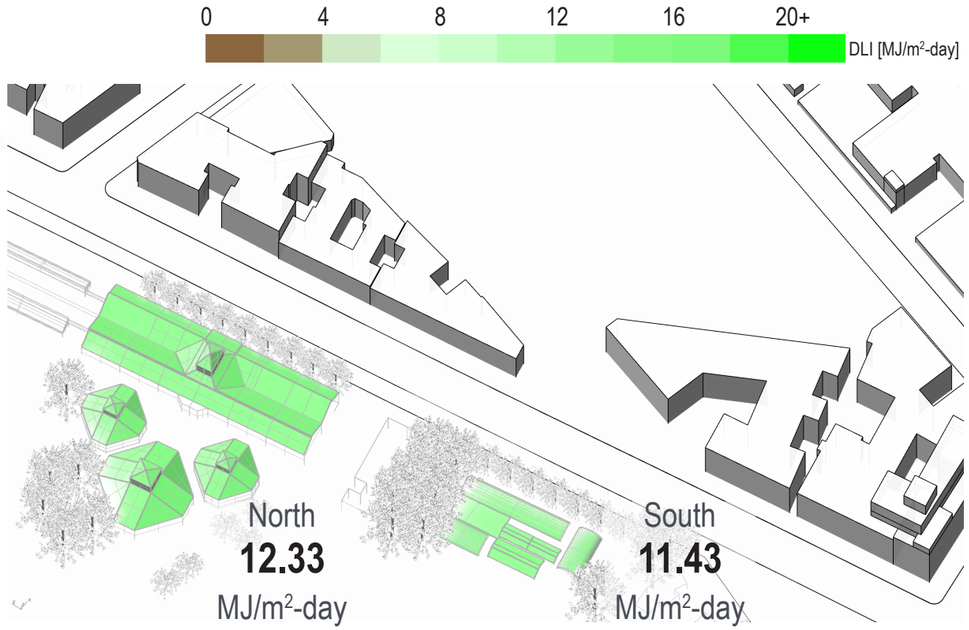
Key Findings:

- Radiation before 9am only account for less than 14% annually.
- Considering existing trees surrounding the greenhouses, the building reduces 6 kWh/m², or 0.4% annual radiation.

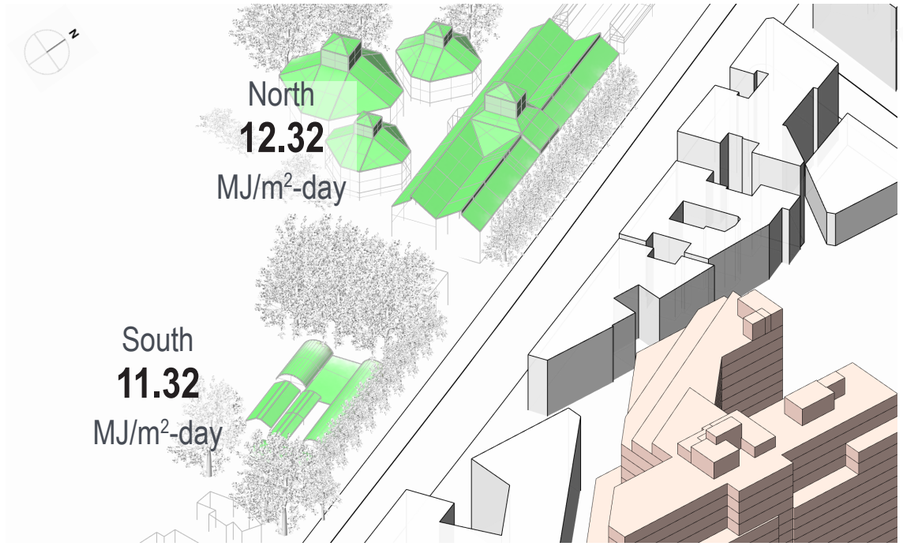
SECTION 3: PAR STUDY (AVERAGE DAILY LIGHT INTEGRAL IN JULY)

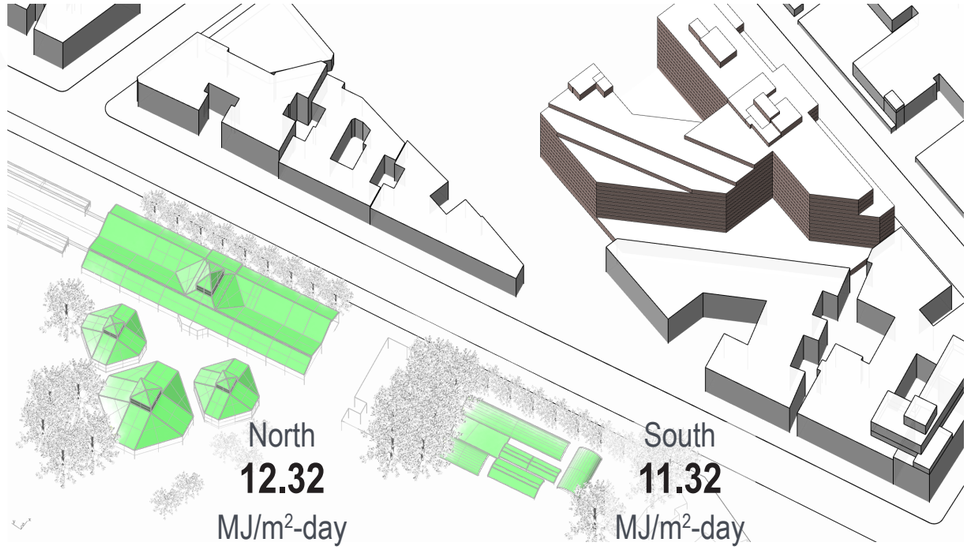
Existing Condition





Proposed Design





Metrics:

- Daily Light Integral (DLI) [MJ/m²-day]

DLI on the greenhouse roof areas as the metric to evaluate the potential shading loss in PAR due to the proposed design.

DLI is typically expressed in mol/m²-day or MJ/m²-day. Each plant species has its own optimal DLI range which will influence growth level and life expectancy.

Key Findings:

- North: The proposed design decreases 0.01 MJ/m²-day, less than 0.1% of the total DLI in July, the peak DLI season
- South: The proposed design decreases 0.11 MJ/m²-day, less than 1% of the total DLI in July, the peak DLI season

TERMINOLOGY & GLOSSARY

Climate Data:

- "USA_NY_New.York-Central.Park.725033_TMY3" is an EnergyPlus Weather file (EPW)
- EPW is an hourly data dictionary of a specific location's real data collected, including solar position, solar intensity, sky brightness, cloudiness patterns, temperatures, humidity, and wind speed etc.
- TMY is short for "typical meteorological year", instead of a specific data year, TMY represents normalized data for the longer time period. TMY3 uses 1991 to 2005 and also 1961 to 1990 if applicable.
- The weather file is sourced from EnergyPlus, funded by the U.S. Department of Energy (DOE) and managed by the National Renewable Energy Laboratory (NREL).

Annual Incident Solar Radiation:

- The measure of the total solar energy that is incident on a specific area over a year.
- Solar energy is measured in kilowatt-hour, a non-SI unit of energy equal to 3.6 megajoules (MJ), or 3412 British thermal units (BTUs).
- Total solar energy in this measure stands for Global Horizontal Radiation, which includes both Direct Normal Radiation and Diffuse Horizontal Radiation.
- Direct Normal Radiation is the amount of solar energy received on a surface perpendicular to the sun rays.
- Diffuse Horizontal Radiation is the amount of solar energy received on a horizontal surface from the sky (excluding the direct sun).

Photosynthetically Active Radiation (PAR):

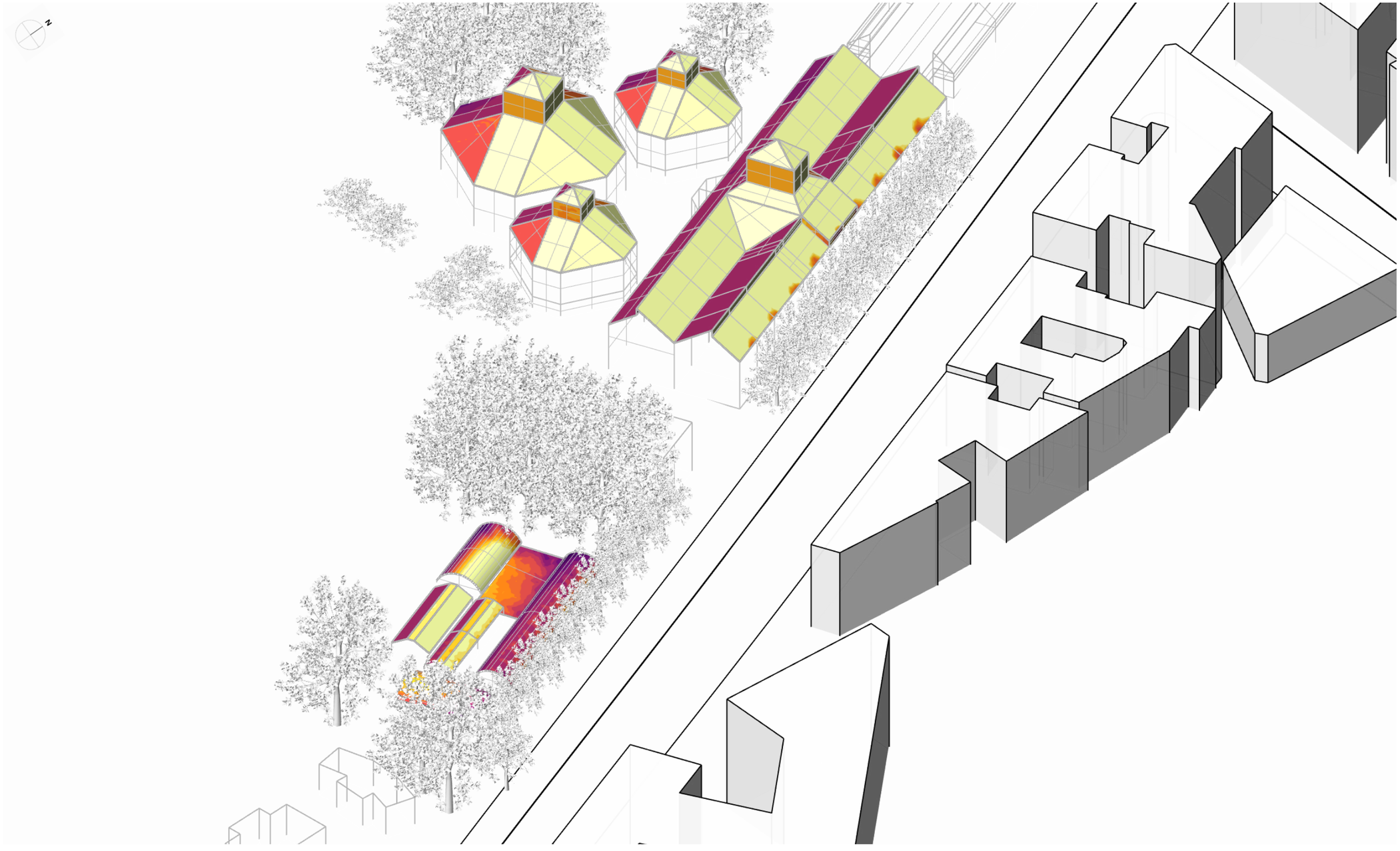
- PAR is portion of the light spectrum utilized by plants for photosynthesis.

Daily Light Integral (DLI):

- PAR is portion of the light spectrum utilized by plants for photosynthesis.

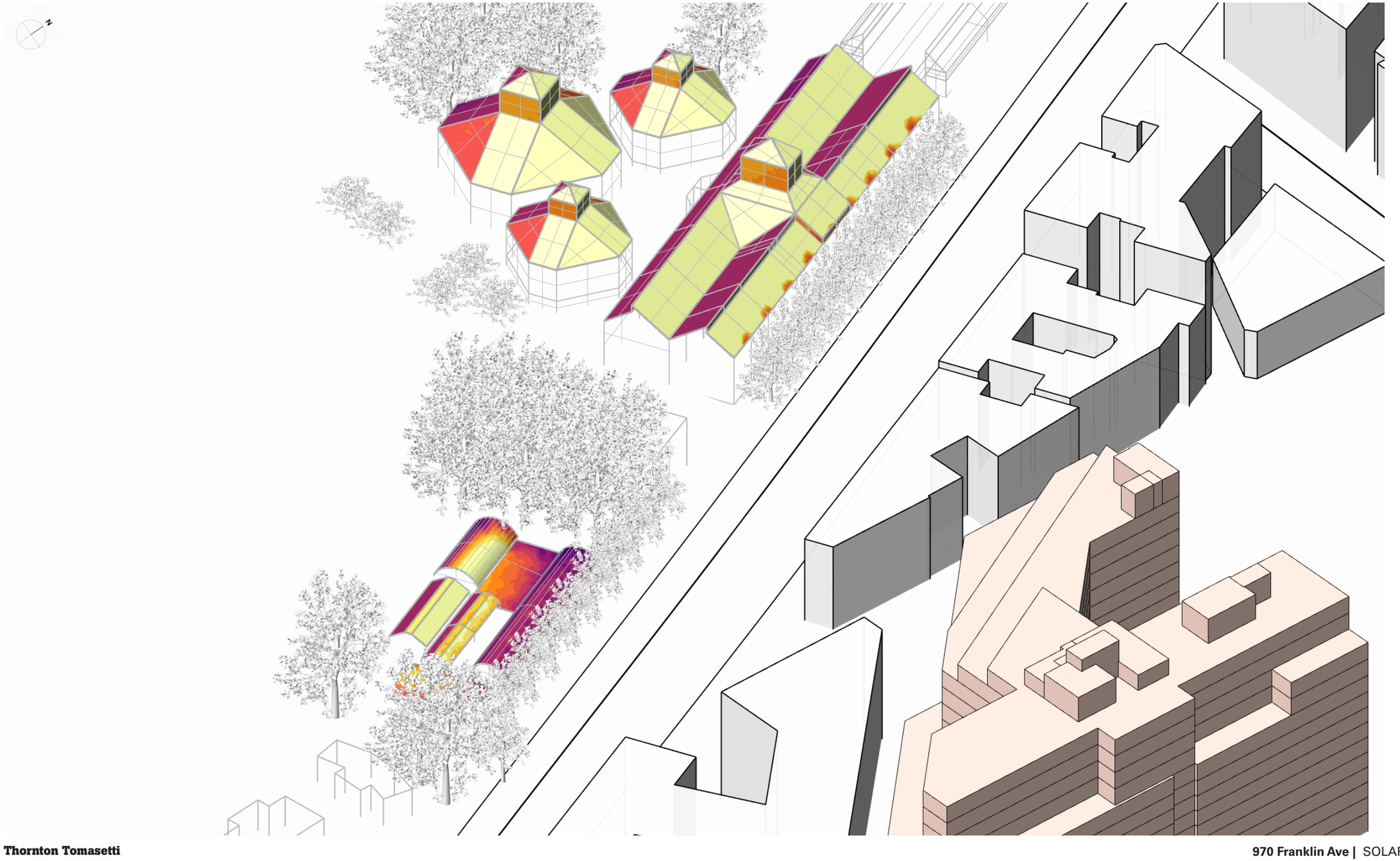
APPENDIX A: RADIATION IMAGES

Existing Condition



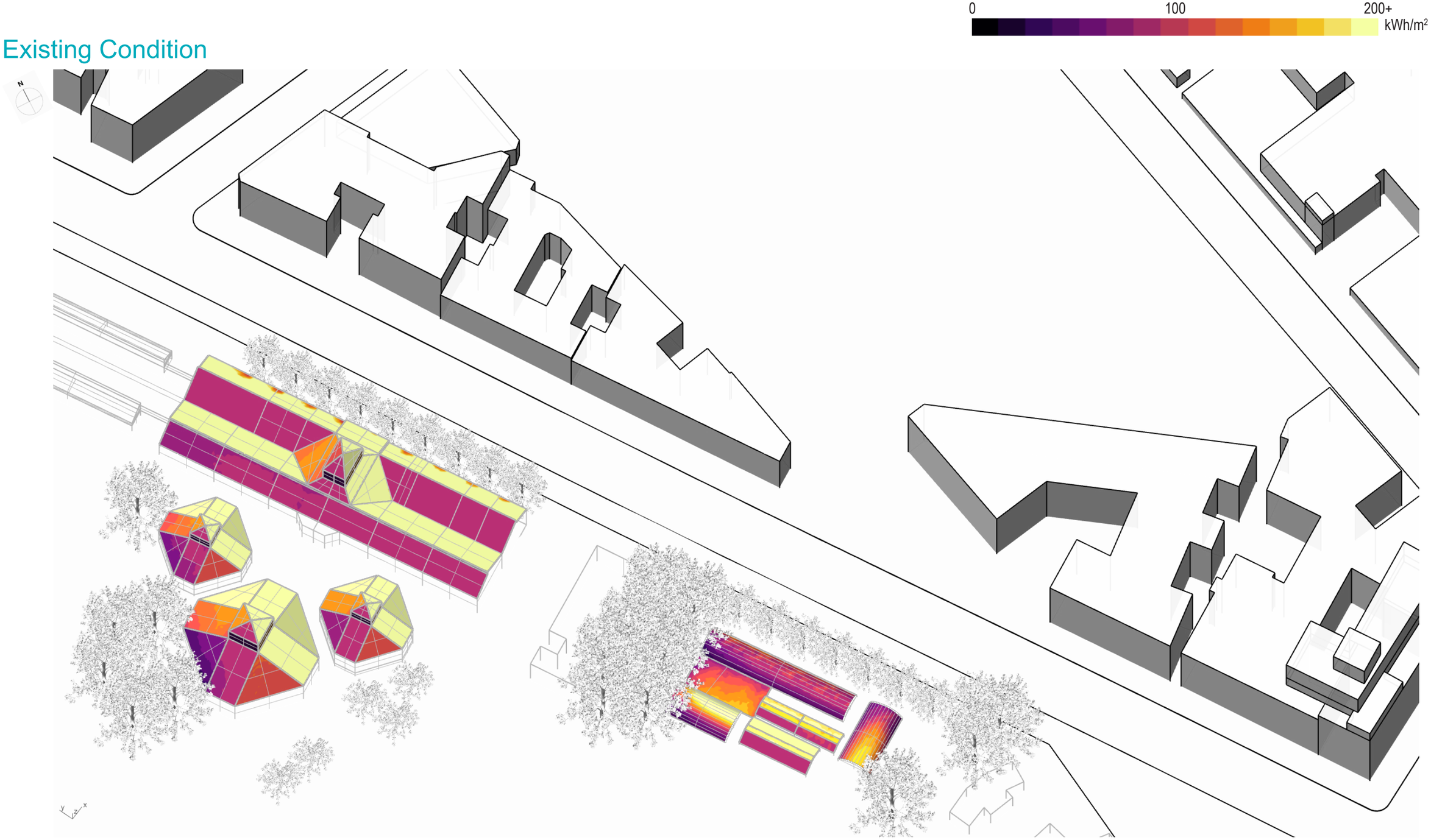
APPENDIX A: RADIATION IMAGES

Proposed Design



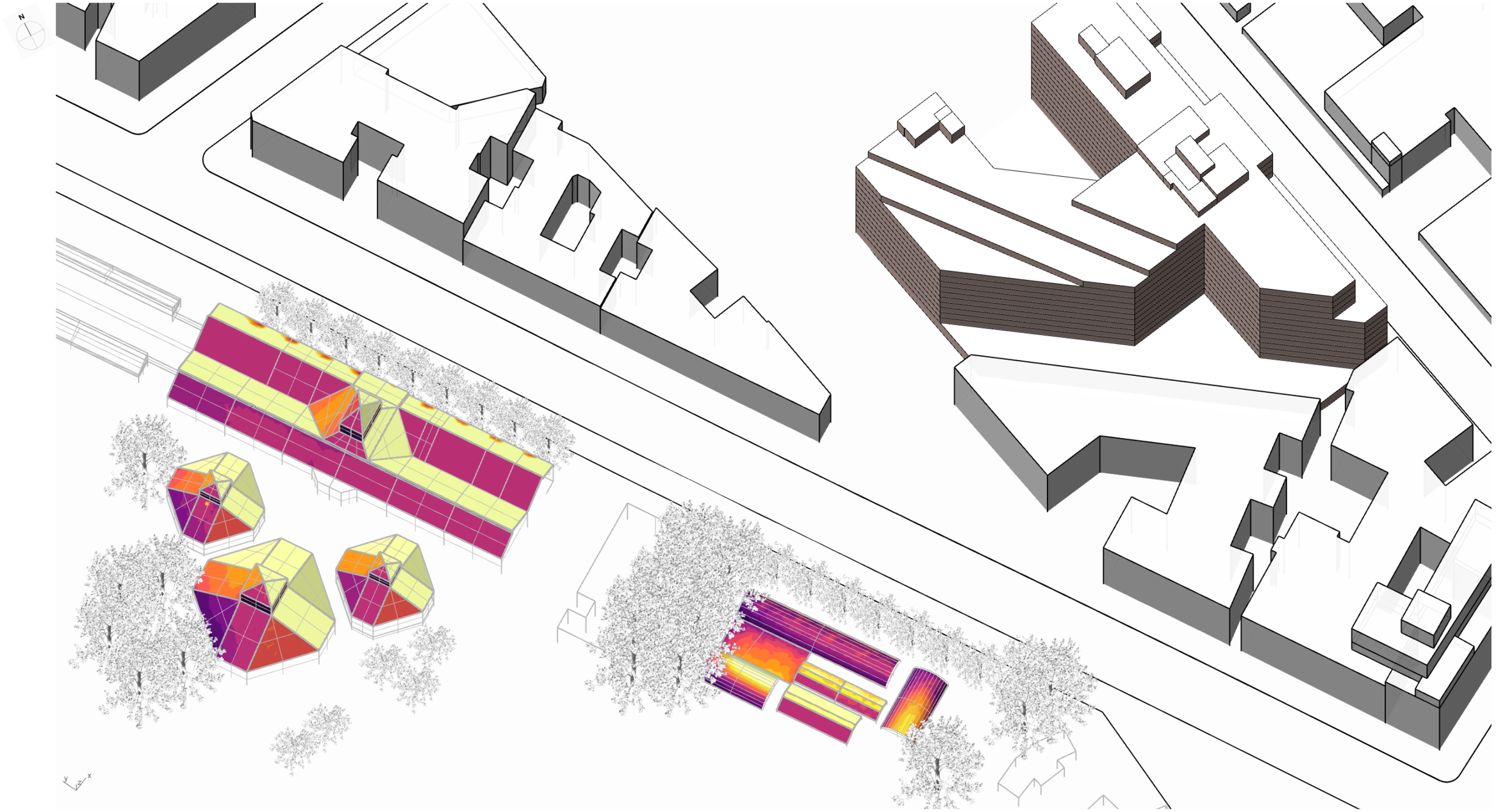
APPENDIX A: RADIATION IMAGES

Existing Condition



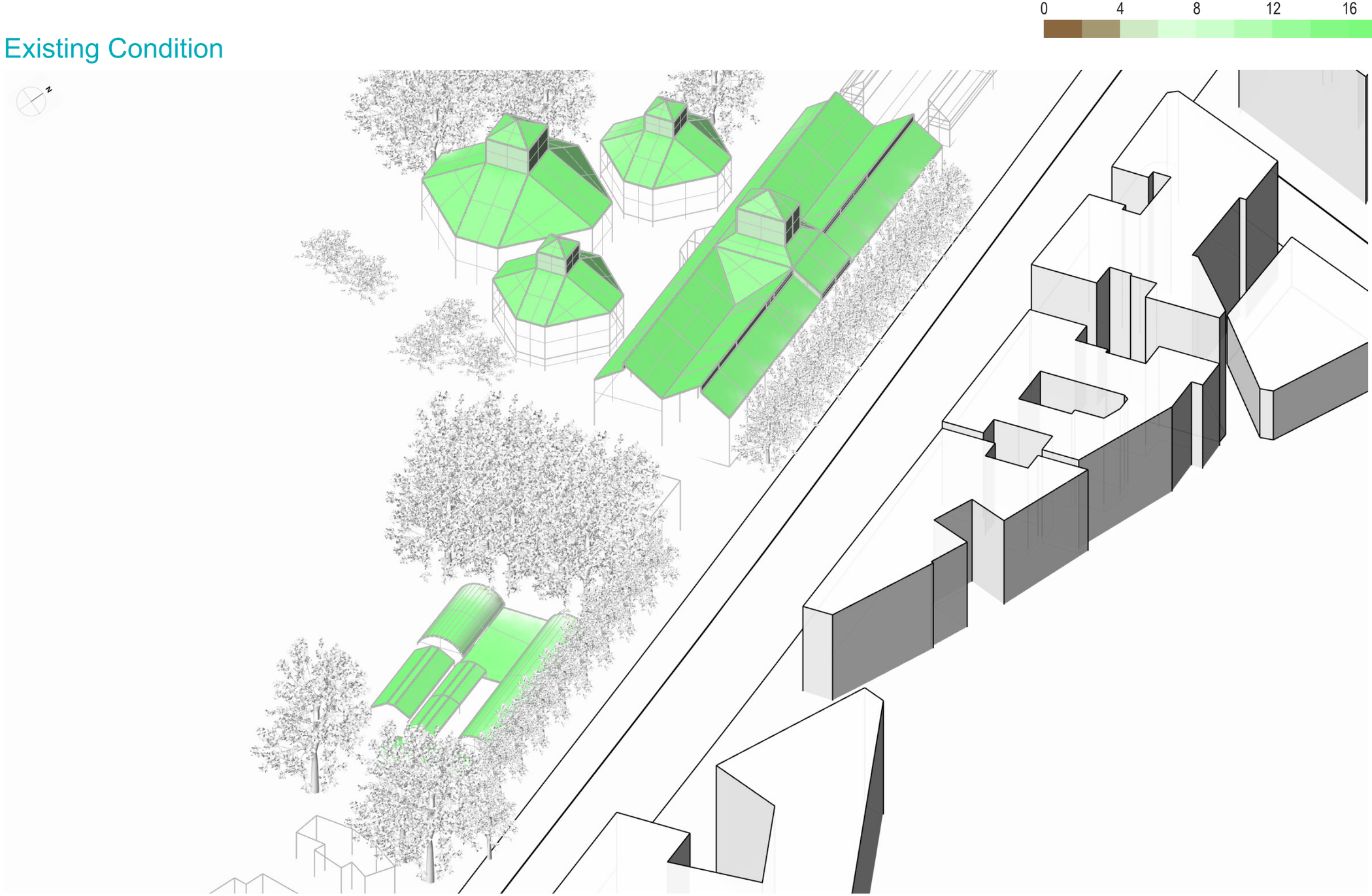
APPENDIX A: RADIATION IMAGES

Proposed Design



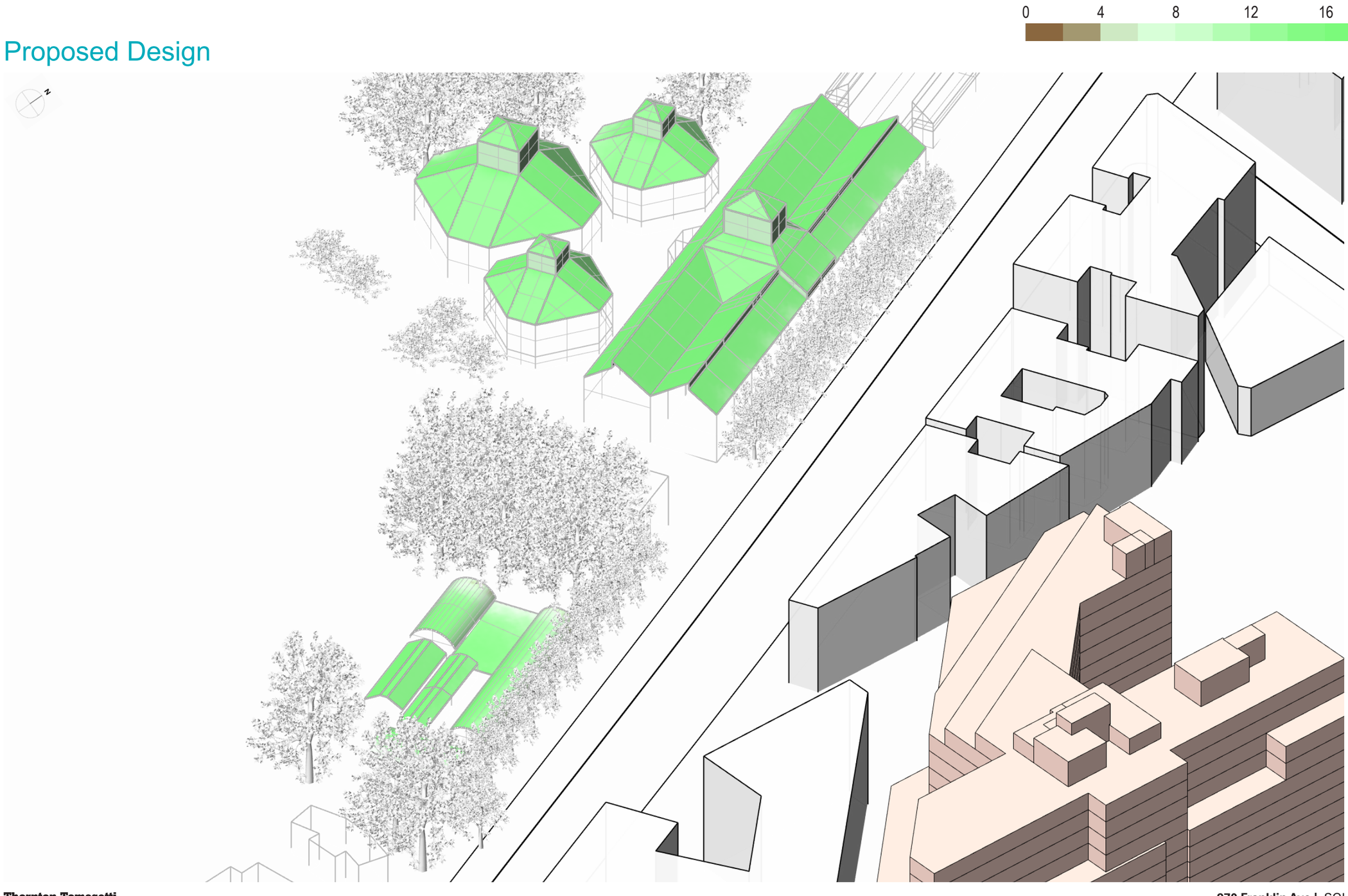
APPENDIX B: PHOTOSYNTHETICALLY ACTIVE RADIATION IMAGE

Existing Condition



APPENDIX B: PHOTOSYNTHETICALLY ACTIVE RADIATION IMAGE

Proposed Design



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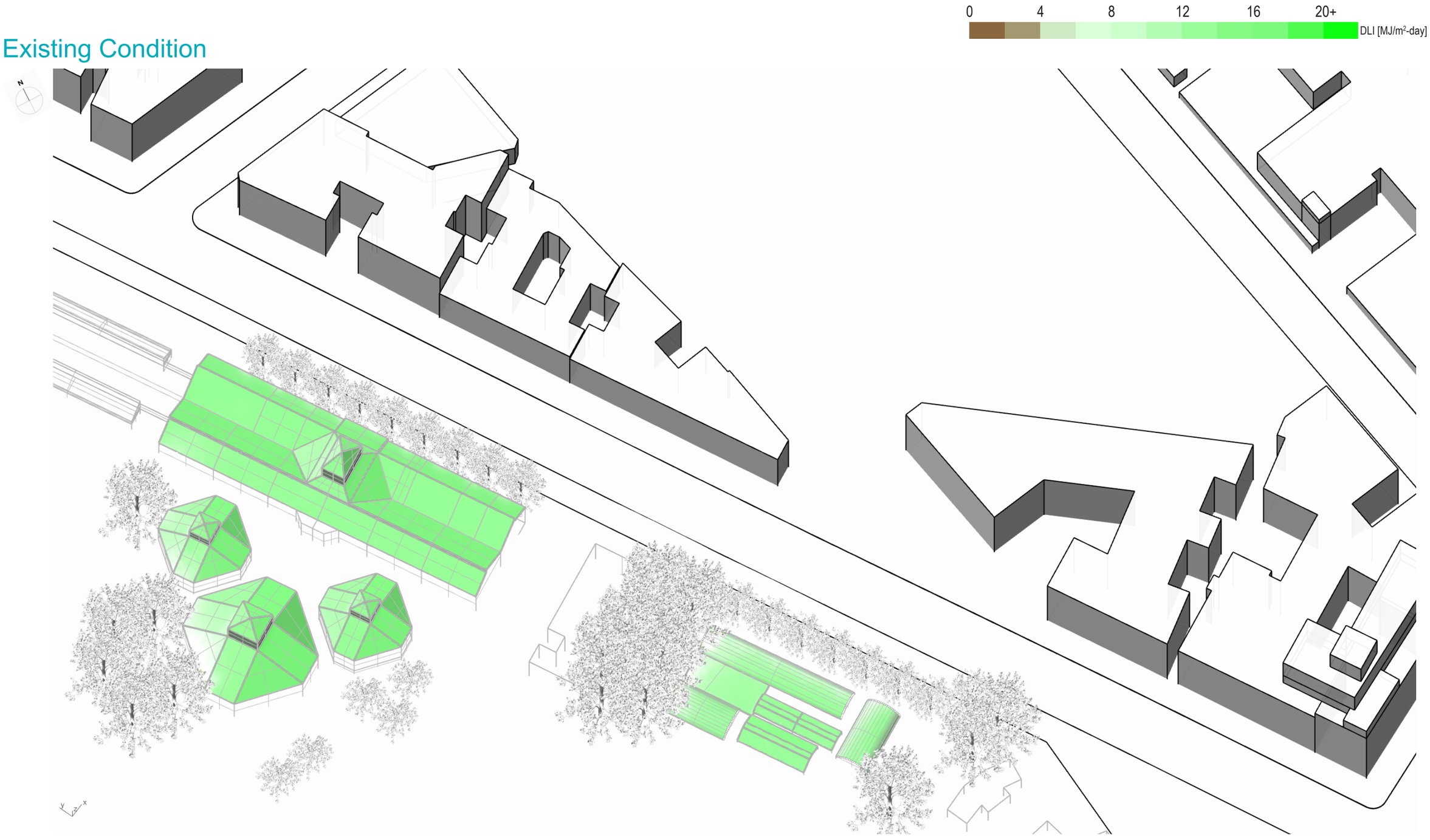
Existing Condition



APPENDIX B: PHOTOSYNTHETICALLY ACTIVE RADIATION IMAGE

Proposed Design