SOLAR OPTIMIZATION IN URBAN DESIGN

WHY SOLAR?
- Peak Oil / Peak Everything
- 21st century Energy Awareness
- Increasing energy demands
- Accessibility and Availability

WHY URBAN DESIGN?
- Building Sector 40% of Energy Market
- Traditional Planning and Design largely ignoring solar:
  Performance left to chance
- Solar Ignorance can have high energy costs.
- Research shows urban orientation and configuration significantly affects energy consumption.

WHY OPTIMIZATION?
- Successful design is a result of compromise
- Trial and error part of the design process greatly accelerated by computational methods
- Optimization guarantees certain standards and qualities imposed by the designers by providing objective estimates of performance.
- Optimizing a solution for multiple design objectives, guarantees the solution with the best performance across all objectives.

WHY CASE STUDIES?
- Complex Relationship between urban environment and the sun: requires unique understanding.
  Each typology interacts differently.
- Contextual Climate data has a huge influence.
  Different approaches in different regions.
- Understanding configurations with different densities.

THESIS PROJECT PHASES

PRELIMINARY RESEARCH
- Identifying the Problem
- Scoping the Scope
- Researching the Case

CASE STUDY RESEARCH
- Highlighting trends and potentials
- Constructing a Review of Typologies
- Characterizing the Design

INTERVENTION PLAN
- Establishing a target site
- Scoping the Framework: plot grid import

ASSESSING PERFORMANCE
- Developing a measure of performance and evaluation
- Evaluating Existing Proposal: Goals and Expectations
- Modeling the Grid: Typology distribution

OPTIMIZATION METHODS
- Modifying the measure: Optimization: Averagecheme Add vs PFI
- Interpreting the results
- Selecting the best result

DEVELOPING THE DESIGN
- Building the plan around the selected geometry
- Delving into the Urban Design
UNDERSTANDING AND EVALUATING SOLAR PERFORMANCE RELATIVE TO URBAN DENSITY

The most clear example is when regarding a simple parameter such as height of a matrix of buildings in regards to the values for it's PSI and the average annual radiation recorded on its surfaces.

When the buildings increase in height, the PSI scales upward while the average radiation recorded decreases. The performance index must reflect our ideal in regards to the relationship between these two recorded values. It must enforce the compromise between building height and the internal space of the building.

It is worth noting in order to increase PSI by an increment.

To understand the desired balance, a few tests were performed in order to see the nature of the dependency between PSI and Average Facade Radiation (AFR)

PRELIMINARY TEST RESULTS.

performance index \( I = \text{PSI} \times \text{AFR} \)

During the test, it became apparent that while PSI increased in linear fashion, with no direct limit to its value, the Average Facade Radiation values fall rapidly at start, with the 1st standards that come across the calculation. A point after which the PSI does not change much, under which it becomes apparent, difficult to apply, and the increase in PSI. After this point one can intuitively deduce the performance values by boosting the PSI with minimal radiation loss.

This result in the inability to obtain an optimum for a performance index that takes into account the same exponent for both PSI and Radiation.

When using \( z \) as exponent to the radiation values however, the curve of the new index over PSI graph displays a curve allowing for a peak value.
Distribution Goals:

- Understanding the grid, and what plots cannot support a certain type that is currently being explored.
- Airing a general idea of how a certain type performs in some of the more difficult conditions from the southern part of the grid.

Observations:

- Since no precedent has been created, the observations from the case studies present the most versatile and flexible of the 4 types.
- Therefore, the 1st iteration will employ a large number of type 4 plots in order to achieve concentrated density values, while other types will be employed in order to achieve concentrated density areas.

Solution Graphs [PSI vs Radiation]

- For PSI vs Radiation: Psi = 1.977 Red = 122.370 T = 30.095

In this particular solution, we can see the highest performance being achieved in the southeast corner of the grid, where the buildings present the highest PSI and Radiation parameters.

The configurations highlighted in red have been identified as the most viable for significant boost in the overall performance of the facade development. In this performance chart, it is evident that the particular solution scores highest on every metric compared to the previous iteration.

*Chosen Solution for Detailing

Iteration 2

Distribution Goals:

- Introducing type 1, with complete liberty in regards to orientation and spacing.
- Attempting to pin point what orientation works best in order to build around it for the next iterations.
- Potential connections could be exploited when available.

Observations:

- The orientation for type 1 seems to vary according to context; more situational than expected. There is no ideal orientation for all contexts.
- Even variations that boost both linear building PSI or U' component PSI in order to achieve highest performance index. Both components of the type have the potential to absorb PSI in detriment of the other. 
- Height difference seems to considerably boost solar access, even within the same type.

PSI = 2.585 Red = 125.371 T = 37.793

Iteration 3

Distribution Goals:

- Attempting to exploit a potential synergy between types 1 and 2, providing additional connectivity and dynamic to the urban fabric.
- Re-configuring the orientation of both types and 2 so that their connections align within the grid.
- Bringing back some type 4 plots to make up for the openness and fragmentation of the newly introduced types.

Observations:

- The attempt was fairly successful, showing that height difference plays a key role in the syzygy. 
- The type U' component yields significantly more performance than the bar component, and thus the better solutions favorize it in terms of PSI.
- The newly reintroduced courtyard typologies also seem to be a big hit in this particular configurations.

PSI = 2.179 Red = 127.497 T = 39.432

Iteration 4

The best solutions from this iteration were near maximum heights for the towers on both the north and south sides, as well as maximizing parts of the 1 and 3 types.

The buildings near the large public space by the waterfront in the north do not have this advantage reflected in their scores.

While the more courtyard formations seem to perform better, those are present in the compact southern grid. It is worth experimenting with shifting one of the middle courtyards for part of the public space invested in the north.

Along side the usual factors before, the type 1 build-ings seem to attain relatively high PSI in this scenario, although on a large to the U' component. 

The height discrepancy while allowing “U” to collect a high performance index still holds the linear component to live-size of 3-4 floors.

PSI and Radiations is also changed in the type 6 present to the walk of the square, making for an interesting overall landscape of the built environment. It seems that height difference is as much a factor as PSI for the more poorly oriented buildings are key.