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Aymeric Delmas

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Solar Potential in Extreme Climate Conditions

Comparative analysis of two district case studies in Norway and Reunion Island

AYMERIC DELMAS

PhD candidate at PIMENT
Research Engineer at IMAGEEN
aymeric.delmás@imageen.re

CONTEXT Due to its combined rugged topography, limited land available and population growth, Reunion must inevitably address the new challenge of **urban densification**. Therefore, new urban forms need to be designed in a climate and context-sensitive way in order to provide low energy, sustainable and comfortable places for people.

Currently in Reunion, most buildings are designed following French building codes with very small and even no consideration of the context, the climatic conditions or the natural resources available. This leads to uncomfortable conditions for occupants, need for air conditioning and high energy consumption.

In this context, **solar urban planning** is a first step towards more urban

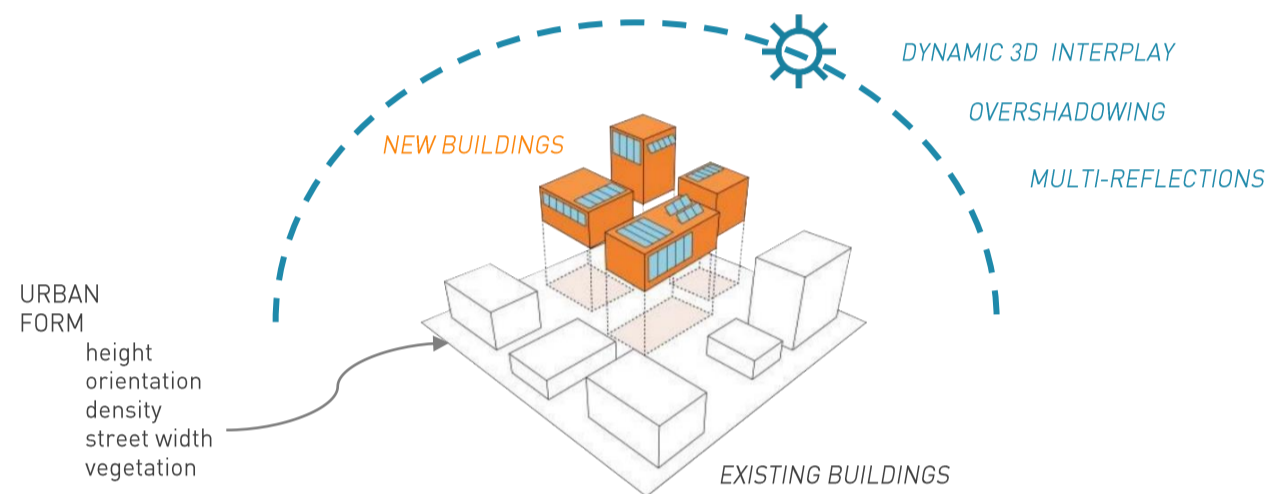
sustainability and climate-sensitiveness by integrating solar active and passive solutions in the urban morphology. Indeed, this unlimited but also under used source of energy can be harvested for PV electric generation, domestic hot water, daylighting and plant growing at the urban scale.

But when looking at densification and solar urban planning together, the **complexity** of the 3d interplay between solar irradiation and the **urban form**, the multiple design constraints and parameters and the impact of new buildings on the existing ones make solar integration a real challenge for designers and urban planners. They need flexible and performative tools for studying such phenomena, exploring and optimising design scenarios.

APPROACH In order to fully exploit the solar energy potential of urban settlements, the proposed approach is to maximise the solar irradiation received by the urban geometry, by both new and existing buildings. This is a way of **limiting the**

adverse solar availability reduction over the existing environment due to the integration of new buildings. To do so, the **geometry-based solar optimisation** method needs to be applied following the hierarchy of scales, to the urban layout first and second to the building form.

Urban densification + Solar urban planning = ?



Multi-scale

1 Urban Layout

Geometry-based

2 Building Form

3 Envelope Fabric

Multi-objective

1 Minimise overshadowing

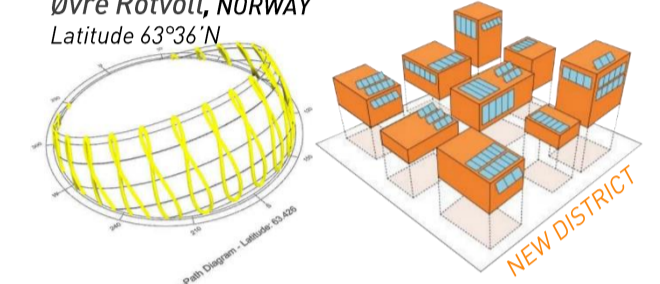
2 Maximise solar collection

3 Maximise comfort

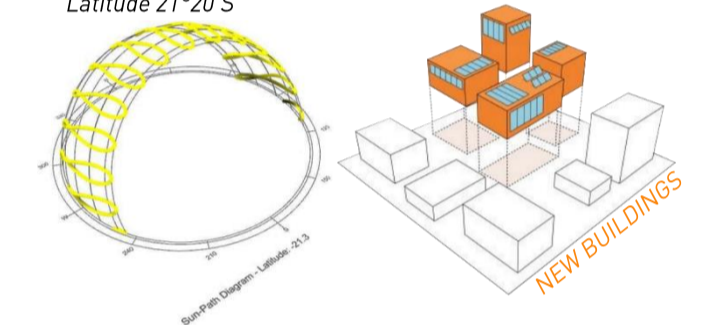
The applicability of the method is tested in two district case studies situated in extreme climate conditions. They are both under a significant densification development and comprise new building projects that were planned following similar text books with no consideration for climate conditions or solar integration. Therefore, in order to **inform these urban rules**, it has been decided to study one urban scenario in both climates.

2 EXTREME LATITUDES

Øvre Rotvoll, NORWAY
Latitude 63°36'N



Ravine Blanche, REUNION ISLAND
Latitude 21°20'S



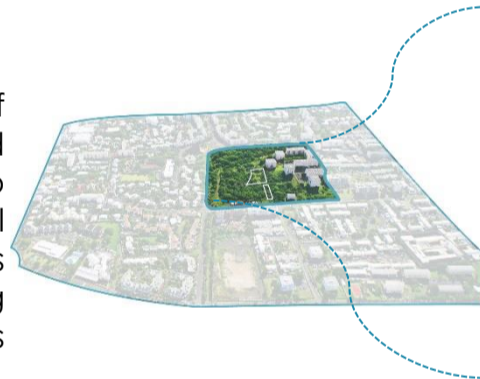
1 DESIGN BRIEF

Existing urban context
ECO-DISTRICT of Ravine Blanche

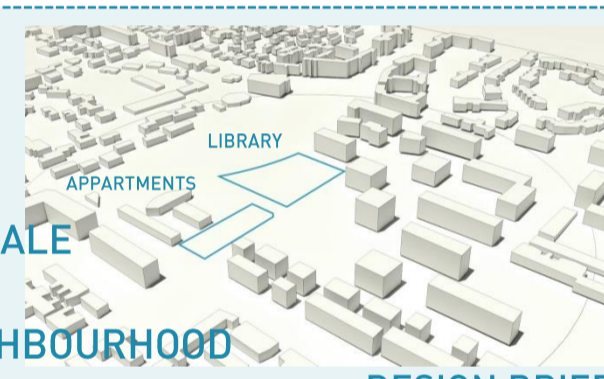
New buildings
LIBRARY
APARTMENTS

DESIGN & OPTIMISATION

The design and optimisation process combines the use of **parametric modelling** with **dynamic solar simulation** and **evolutionary algorithm** for solar urban planning. Thanks to their **flexibility**, it is possible to maximise the solar potential of a district at various scales with simple transformations while limiting solar availability reduction over the existing buildings by taking the complex overshadowing effects and **mutual reflections** into account.



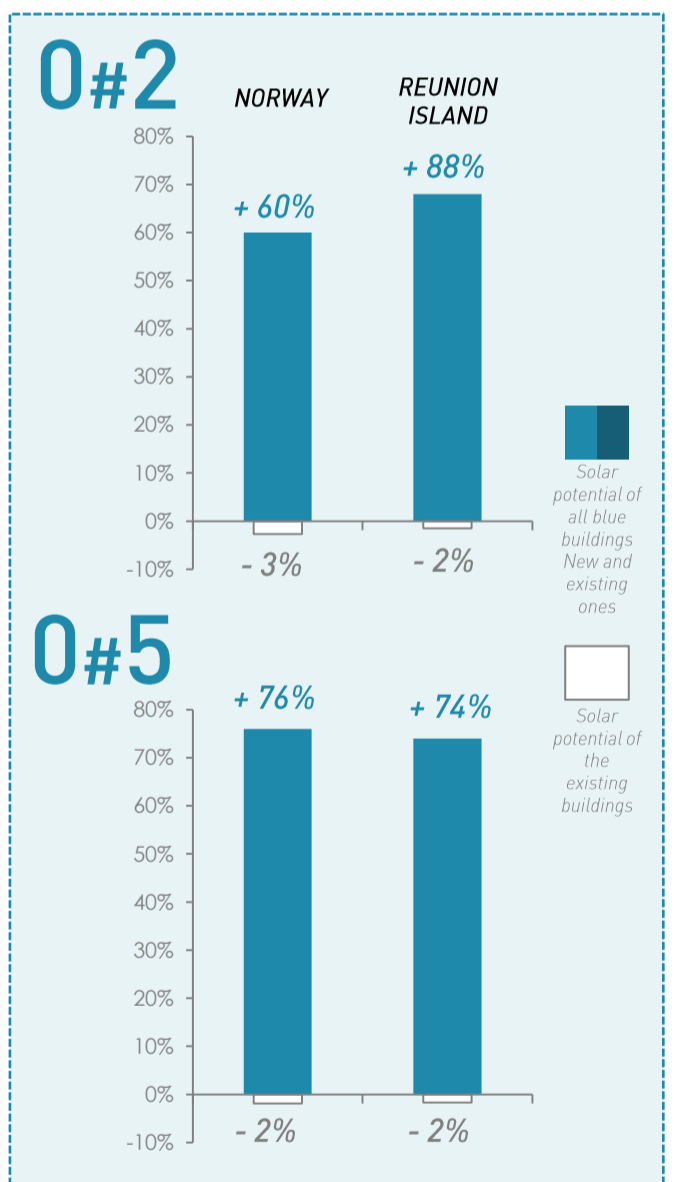
SCALE
NEIGHBOURHOOD



DESIGN BRIEF

Integration of 2 new buildings among existing ones with assigned parcels

SOLAR POTENTIAL



TOOLS

Rhinoceros

Geometry

Grasshopper

PARAMETRIC MODELLING

Parameters

Ladybug

Direct overshadowing

Diva4Gh

RADIANCE-SOLAR ANALYSIS

D

Evolutionary

SCALE OPTIMISATION

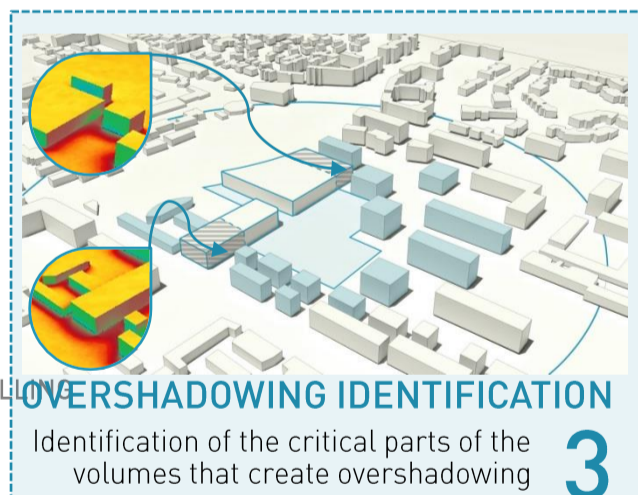
MULTI

Galapagos

Evolutionary

SCALE OPTIMISATION

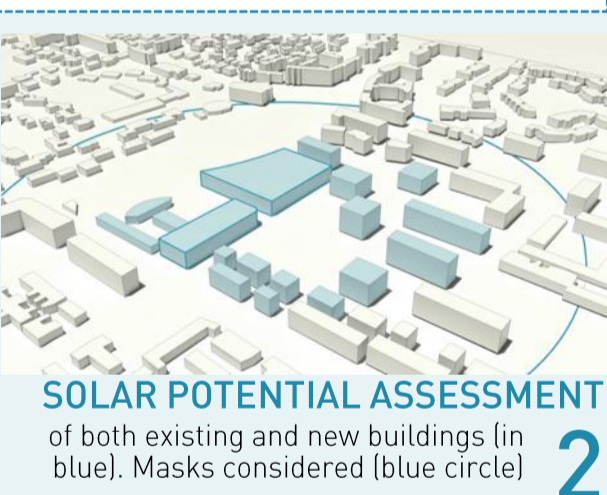
MULTI



OVERSHADOWING IDENTIFICATION

Identification of the critical parts of the volumes that create overshadowing

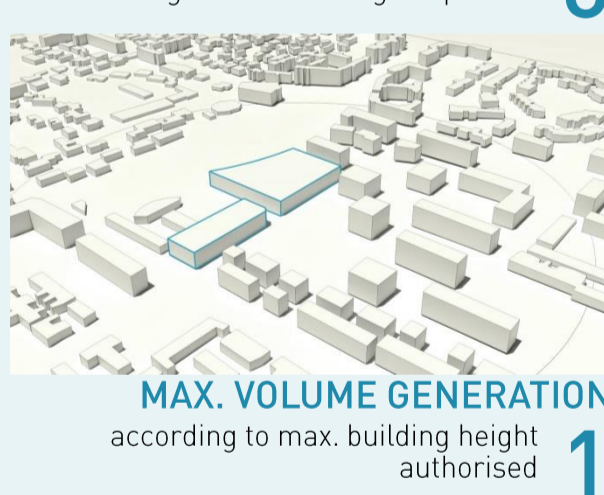
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SOLAR POTENTIAL ASSESSMENT

of both existing and new buildings (in blue). Masks considered (blue circle)

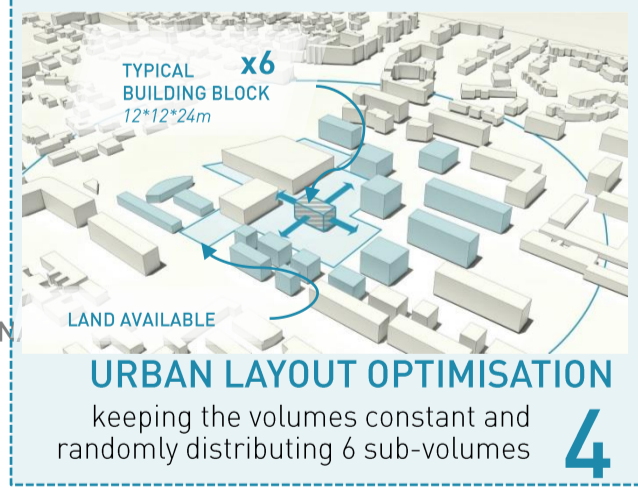
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MAX. VOLUME GENERATION

according to max. building height authorised

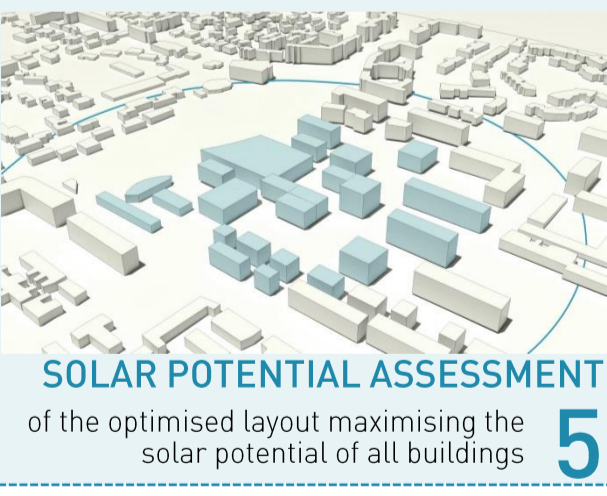
1



URBAN LAYOUT OPTIMISATION

keeping the volumes constant and randomly distributing 6 sub-volumes

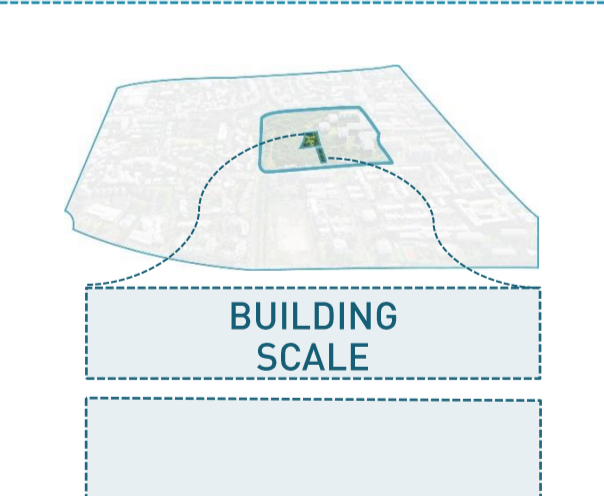
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SOLAR POTENTIAL ASSESSMENT

of the optimised layout maximising the solar potential of all buildings

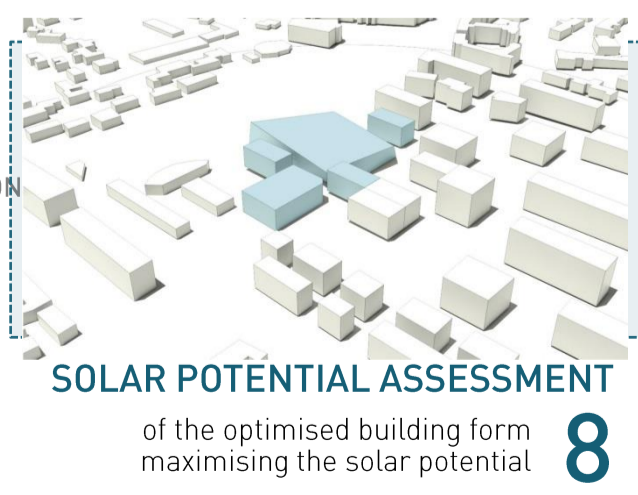
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BUILDING SCALE

Roof rotation [-10°W to 10°E] and facade slope [-10°S to 10°N] transformations

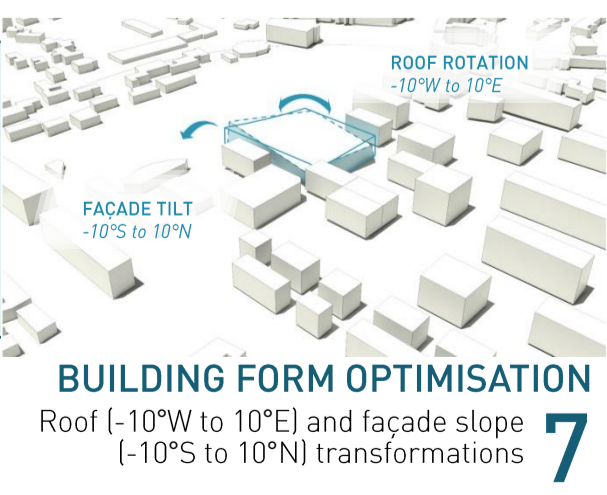
7



SOLAR POTENTIAL ASSESSMENT

of the optimised building form maximising the solar potential

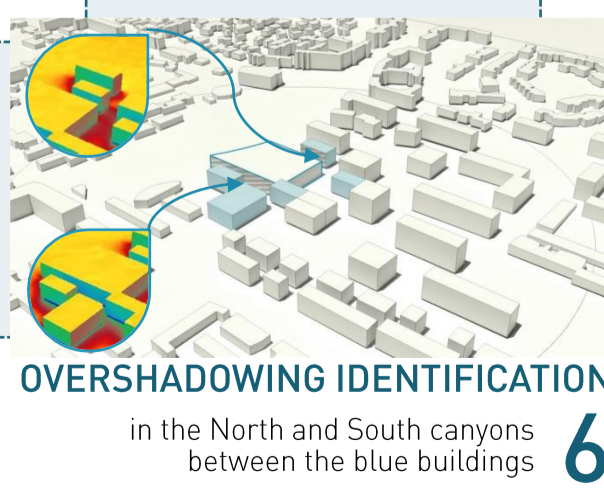
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BUILDING FORM OPTIMISATION

Roof [-10°W to 10°E] and facade slope [-10°S to 10°N] transformations

7

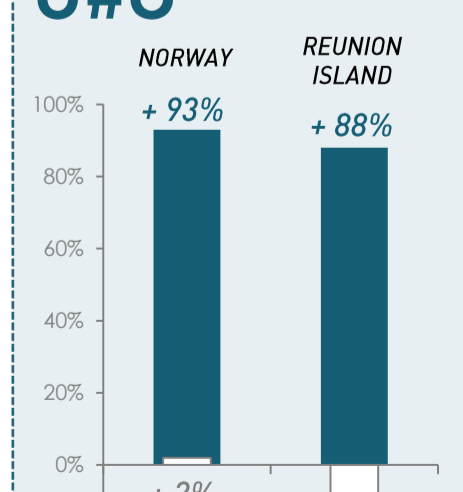


OVERSHADOWING IDENTIFICATION

in the North and South canyons between the blue buildings

6

6#8



CONCLUSION

This study is a first step towards more **urban climate-sensitiveness**. This flexible and multi-scale approach will be further developed by integrating thermal and airflow dynamic simulations in the workflow. The aim is at the end to support the design of optimised bioclimatic buildings in dense tropical urban areas using parametric modelling and climate-based tools.