Evaluation of solar energy potential for urban residential buildings based on deep learning algorithms

Introduction and background

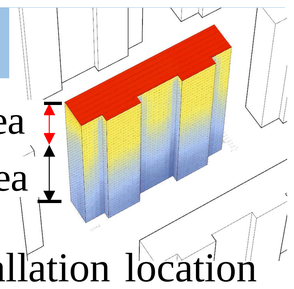
(1) The development of building integrated photovoltaics (BIPV)

At present, building integrated photovoltaics (PV) is an important measure to promote energy conservation and urban low-carbon development.

(2) The utilization potential of solar energy in urban residential buildings

Urban residential buildings, which occupy the main part of a city, have a great prospect to effectively utilize the solar energy.

However, the diversity of residential buildings and complexity of urban environment make it difficult to efficiently utilize solar energy.



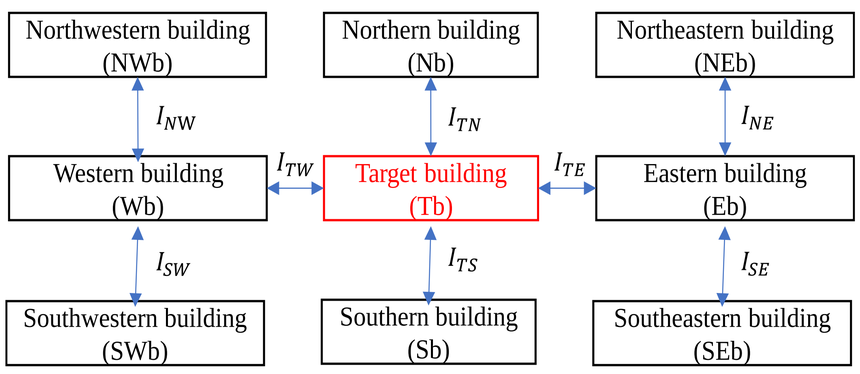
- How to define the suitable installation location of PV modules on building surfaces(roofs/facades) considering the surrounding environment ?
- How to determine the solar utilization potential of buildings based on block parameters ?

Research purpose

- Evaluate solar energy potential for residential buildings based on a parametric approach and deep learning algorithms.
- Propose the PV installation strategies for building roofs and facades.

Methodology

(1) Block scale parametric modeling

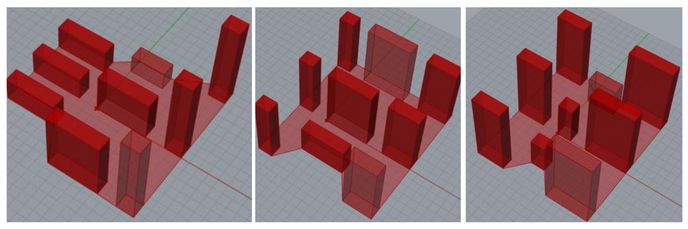


26 Block parameters are set in a certain range:

- Building height (H): 3-99 m
- Building interval (I): 2.7-60m
- Morphological parameters(M): tower, slab A, slab B.

(2) Automatic generation of blocks

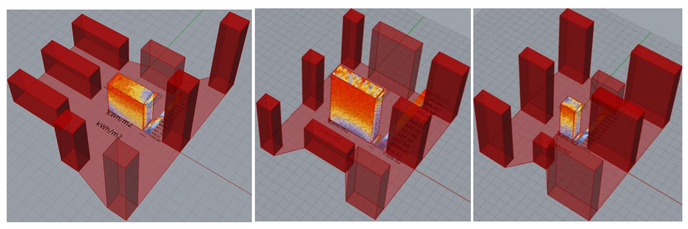
Rhino



7000 cases are randomly generated

Python

Solar radiation simulation



(3) The assessment approach of solar energy potential

- PV power potential (Solar radiation potential)
- PV installation ratio

(4) Deep neural network (DNN)

- Construction of training database based on solar radiation analysis results.
- Training, validation and prediction of solar power potential.

Results

(1) Solar energy potential for buildings

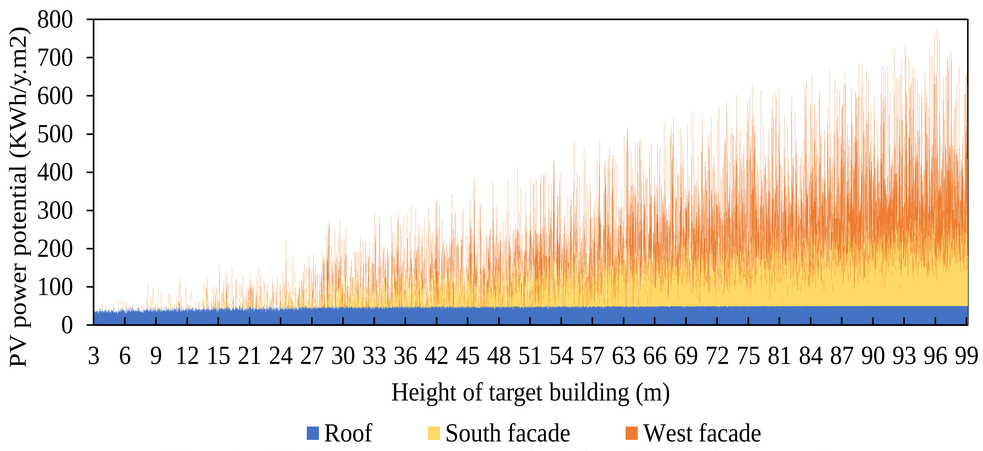


Fig 1. PV power potential for building surfaces.

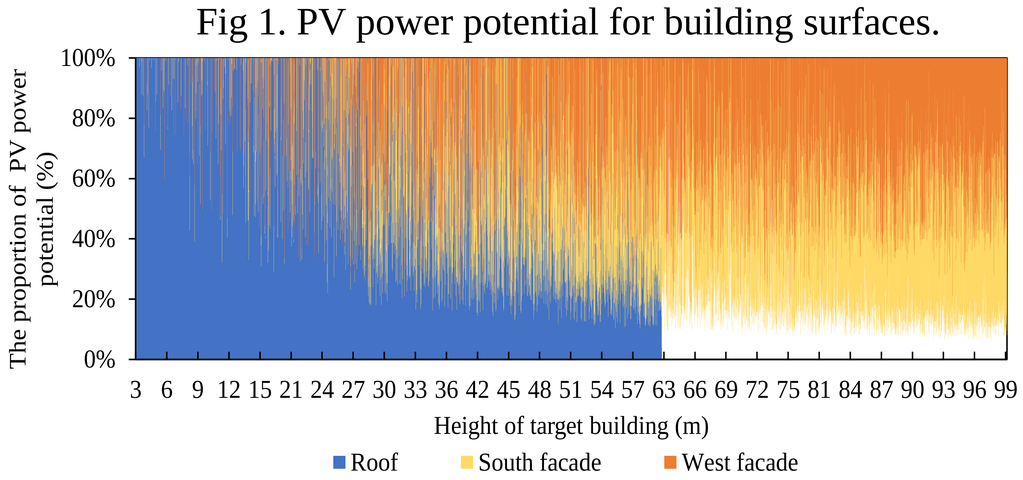


Fig 2. The proportion of PV power potential.

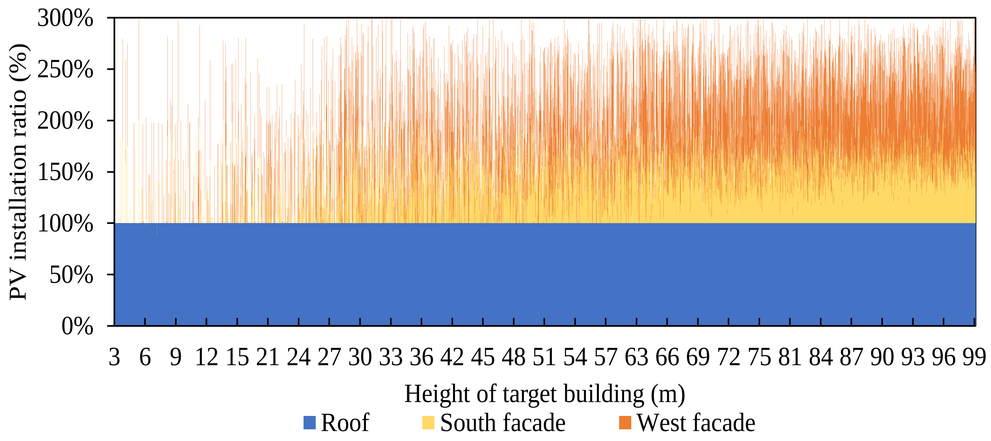


Fig 3. PV installation ratio for building surfaces.

PV power potential (Fig 1, Fig 2):

- Roof PV power potential, with values around 45.7 KWh/m2.y, present a stable power generation potential.
- As $Height_{Tb} \geq$ 24m, the average PV power potential of south and west façade can reach 87.6 and 75.2 KWh/m2.y, and their maximum proportion can reach 80.7% and 83.2%.

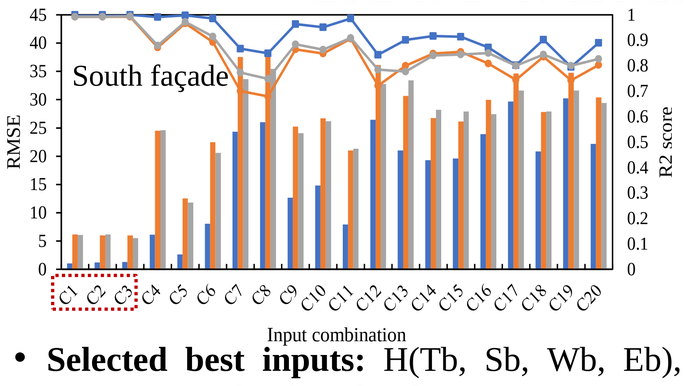
PV installation ratio (Fig 3):

- All the roof area are recommended to install the PV modules.
- When $Height_{Tb} \geq$ 24m, the south and west façade are suitable for PV installation, with the average PV installation ratio of 47.5% and 38.4%, respectively.

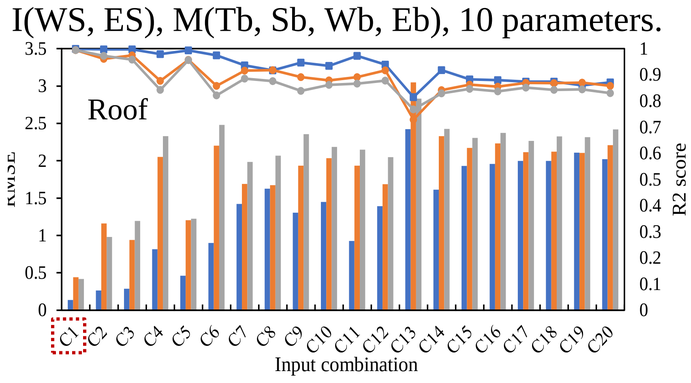
(2) DNN prediction of PV power potential

Prediction f solar power potential with minimal input parameter combinations.

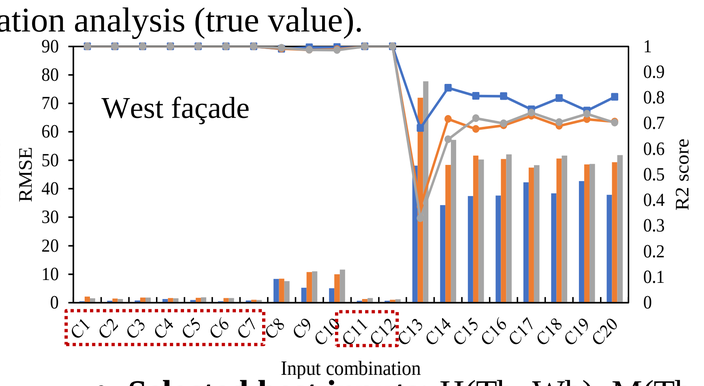
Fig.4 The errors between prediction of solar power potential by deep learning and the result of solar radiation analysis (true value).



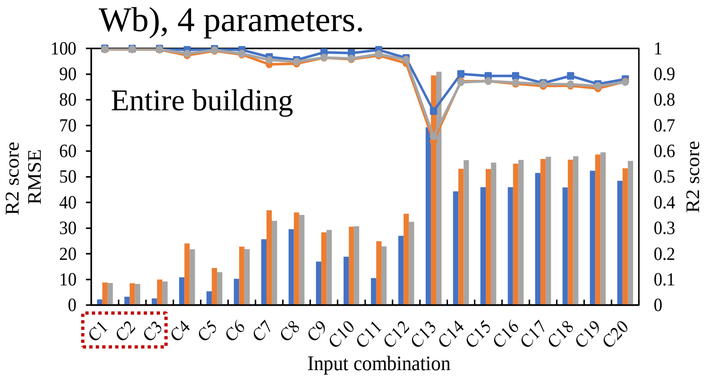
- **Selected best inputs:** H(Tb, Sb, Wb, Eb), I(WS, ES), M(Tb, Sb, Wb, Eb), 10 parameters.



- **Selected best inputs:** H(Tb, Sb, Wb, Eb, Nb), I(TN, TS, TW, TE, WS, ES, WN, EN), M(Tb, Sb, Wb, Eb, Nb), 18 parameters.



- **Selected best inputs:** H(Tb, Wb), M(Tb, Wb), 4 parameters.



- **Selected best inputs:** H(Tb, Sb, Wb, Eb), I(WS, ES), M(Tb, Sb, Wb, Eb), 10 parameters.

- Final image of the research: promoting carbon neutrality for the city.

深層学習に基づく都市住宅の太陽エネルギー利用可能性の評価

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Ooka Lab. and Kikumoto Lab.