The key problems to be solved in urban design which is facing solar energy should be that how to judge the matching degree between ability of solar energy collection and the energy demand of function configuration in one 3D architectural form scheme with given function configuration. This directly affects the energy allocation problem of each block on urban scale and also the size and location of solar energy collection base on architectural scale. If the existing research can estimate the energy demand of function configuration, then evaluation of solar energy collection ability of architectural form scheme with given function would be the key to the question.
This study uses parametric model generation and evaluation technology, according to the current solar installation specification and technical level, to search for a way to evaluate urban design schemes quantificationally. For any architectural form of given function, this model automatically arranges the location and size of solar energy collection base and finish the assessment of annual sunshine radiation. Based on the quantitative indicator, this study try to realize multi-alternative comparison in different function configuration schemes or different building density schemes during urban design progress under the premise of the same construction. This study tries to provide technical support for solar perspective of urban design.

GENERATION OF PARAMETRIC SOLAR PANEL LAYOUT

Evaluation of solar energy collecting capability for any given urban design requires the completed installation conception of solar energy collecting equipment. This assessment is used to compare functional configurations and the reasonability of building densities between different concepts in process of urban design. It is always in the preliminary phase. At this stage, the 3D forms only implicate the development of volume. With the rough functional orientation of each body, the concrete definition of the surface to organize the installation partition of solar energy collecting units does not exist. Precisely because of these uncertainties, the parameterized generating technology based on daily design experiences becomes a proper solution.
Here are two models that come from two kinds of parametric generating process. One is named surface model (S-model)which is used for estimating the capacity of solar energy collection on building surfaces by simple division(Table 1).The other is named practical model (P-model)which is used for estimating the capacity of solar energy collection more practically according to the existing level of technology and common photovoltaic product specifications(Table 2).

Table 1. *Generation logic of S-Model*

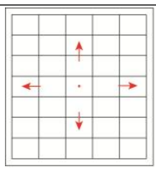
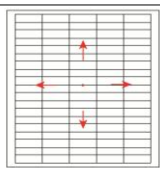
Building types	Storey height (m)	Laid rules of roof(m)	Size of unit on roof (m)	Laid rules of facade (m)	Size of unit on window (m)	Size of unit on facade (m)
Residence	2.8		3.6*3.6		3.6*1.8	3.6*1.0
Office	4.5		7.2*7.2		7.2*2.5	7.2*2.0
Commerce	4.5		10.8*10.8		10.8*1.5	10.8*3.0

__Table 2.__ Generation logic of P-Model

Building types	Storey Height(m)	Laid rules of roof(m)	Size of unit on roof(mm)	Laid rules of facade(m)	Size of unit on facade(mm)
Residence	2.8		1640*992*35		1640*368*35
Office	4.5				1640*524*35
Commerce	4.5				1640*524*35

In S-model (Table1,Figure 1), solar energy collection units will be parallelly installed on east facade, south facade, west facade and roof. According to diverse building functional orientations, the typical structural column distance will be used to generate the length of the roof unit side also the width of the facade. Meanwhile, the unit vertical dimensions can be in terms of the usual story height of buildings and the height of the window center segmentation during the facade design. It is also supposed, that the placing of facades start from its middle point right, left and upwards. The collection units on the facade is composed of windows and panel parallel to the facades. The spread of roofing begins from center to its surroundings. A set of generating logic will be produced. Structural column distance, story height and segmentation of facades can be inputted in the generating software.

P-model(Table 2,Figure 2) is generated according to the experience of practical projects, so the way to install solar energy collection units in this model is more closer to real project. South facade and roof is chosen to install units. On south facade, PV panels are combined with sunshade components with an angle of 15 degree (the best angle for solar energy collection in Shanghai by practical experience).On the roof, PV panels arrange in an array with an angle of 15 degree and also stand on distance of 0.5 meters above the ground. They need to maintain a certain distance in case that there will be some shadows on panels on 9:00am in winter solstice day. For a same system, select the same kinds of product specifications could reduce additional energy loss, thus this model choose the specifications of polycrystalline PV panels commonly used in practical engineering projects as module. In practical projects, if there are some shadows on panels between 9:00am to 15:00pm in the daytime, it will make the whole system reduce efficiency by a large margin. So in P-model, if the area on the surface doesn't satisfy the conditions, it will be forbidden to install panels.

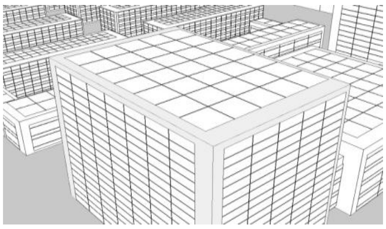


__Figure 1.__ S-Model

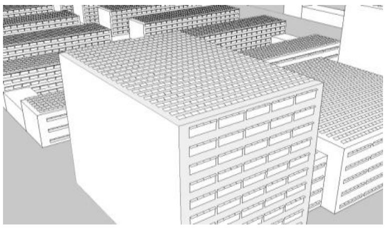


__Figure 2.__ P-Model

Nowadays there are numerous kinds of solar energy collection technique so that designers will have more choices. This installation strategy will lay the foundation of that different parts of the building can adopt different acquisition technology and further study can get related index to convert into a corresponding radiation.

DESIGN EVALUATION AND ITS DEMONSTRATION

In order to explain the process of formation and evaluation above-mentioned better, this study choose the same block under the same development intensity and evaluate the capacity of solar energy collection of 6 design schemes (Figure 3,4,5) separately in different building density (both 36.5% and 19.4%) and three different oriented functions (residence, office and commerce) in order to demonstrate how parametric generation and evaluation technique can help for comparing multi-scheme designs on the initial stage. To be specific, the plot ratio of these schemes is 2.2, the height limit of buildings is 100m，the high building density is 36.5% and the low building density is 19.4%.With the continuous development of solar energy technology, almost every architectural surface with possibility of receiving solar radiation possesses the developing potentiality. Aimed at the comparison of the collecting capabilities after the installation of collecting plates applied in practical use cases, the solar energy collecting models of different solutions will be simulated to estimate the utilizations of solar energy. 3D urban design from Rhino platform will be input into the parametrically generating and evaluating program based on the method of actual engineering design. The generating logic is programmed in Grasshopper. And the amount of solar energy radiation will be calculated in Ecotect, which is driven by Geco. The result includes the quantitative evaluation like Excel table (Table 3) and models from Ecotect (Figure 3,4,5) to guide the following design of concrete architectural morphology to utilize the position with high radiation.

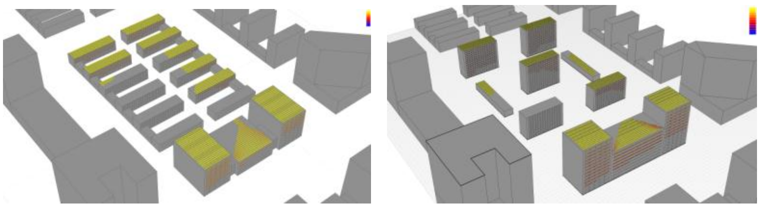


Figure 3. *Plan A and plan B （residence oriented scheme）*

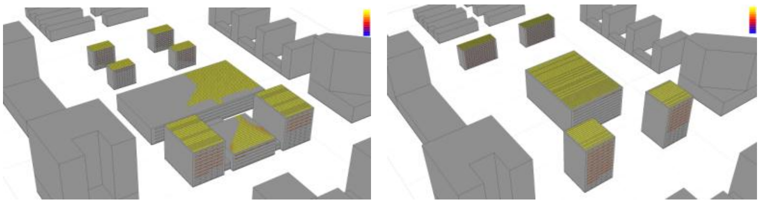


Figure 4. *Plan C and plan D （commerce oriented scheme）*

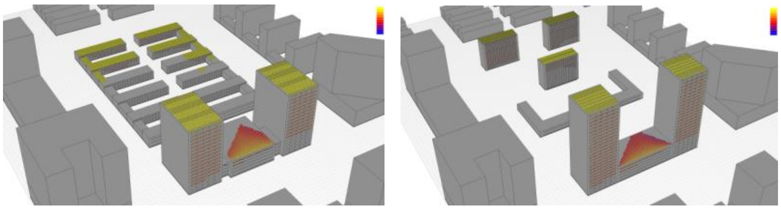


Figure 5. *Plan E and plan F （office oriented scheme）*

Table 3. Evaluation report of Plan-A

Building types	Mounting position	S-Model		P-Model	
		Sun radiation accumulation in one year (MWh)	Solar radiation per unit area (MWh/㎡)	Sun radiation accumulation in one year (MWh)	Solar radiation per unit area (MWh/㎡)
Residence	Facade	1508	0.233	895	3.377
	Roof	640	0.204	2447	1.601
Office	Facade	320	0.065	252	2.355
	Roof	87	0.049	1972	3.217
Commerce	Facade	113	0.042	6	0.400
	Roof	134	0.044	507	1.470
Total		2806	0.127	6079	2.116

DISCUSSION

Firstly, the laying method according to the solar elevation angle is better than the method that laying parallel on the surface of the architecture. Within Table 3, the area of radiation-received surface in S-model is far larger than in P-model. However, the average available solar radiation per unit area is on the contrary, which means the return rate of sunshade panel component is higher than the ones on surface. In practical projects, these declining panels protect themselves from water-logging and dust.

Secondly, the research of the shade system on the facade of residential building and on the roof of office and commercial buildings have a far influence on solar energy and building integrated design. Comparing with the office and commerce, the collecting panels with shade on the surface of facade of residence have more potential than the ones on the roof. In the office building, the production energy of facade and roof almost on the same level, while in the commercial building, the advantage of production energy of roof is much more obvious (Table 3).

Thirdly, the “high-thin type” project with less covered area can get higher rate of potential solar energy utilization than the “short-fat type” project. Because it occupies little land and the shelter between buildings are small. With the 6 projects (Table 4), it is suggested: inside a given projects, with building density decreasing, the solar radiation collected by the S-model decreases, but the utility rate of potential solar energy in P-model increases when density decreases.

Fourthly, building density has smaller influence on residence and office projects, but has a larger influence on the commerce projects. In all the projects, with building density decreasing, the cumulative amount of the annual solar radiation in actual engineering projects are 7% (residence), 27% (commerce) and 8% (office) in difference. In table 4, the rate of potential solar energy utilization of all the projects changes with the building density. The commerce projects have the highest annual cumulative solar energy. It is possible that a best building density for the certain project based on the shadowing relationship of surroundings can be found.

Table 4. *Capacity of solar energy collection in six schemes*

Scheme	Dominant function	Building density (%)	Sun radiation accumulation in one year (MWh)	Sun radiation accumulation of practical scheme in one year (MWh)	Potential solar energy utilization (%)
A	Residence	36.50	2806	6079	216.7
B	Residence	19.40	2641	6518	246.8
C	Commerce	36.50	1701	5726	336.7
D	Commerce	19.40	1529	7281	476.3
E	Office	36.50	2366	5554	234.7
F	Office	19.40	2351	6019	256.0

And lastly, due to the different forming rules of residence, commerce and office buildings (because each of them has its own economic plan size, story height and floor). If designers need to adjust the ability of solar energy collection by adjusting the proportion of functions in one project, the influence of commerce, office and residence decreases one after another.

Those discussions only come from the comparisons of the 6 projects which still have some limitations. However, if designers can study on more urban design projects with this kind of parametric generation and evaluation technology, it is possible that, we can find some design principals on the control of ability of solar energy collection.

CONCLUSIONS AND FUTURE WORK

With the support of parameterized generating and evaluating technology present this article that the assessment of solar energy collecting capability can be conducted for a given urban design, based on which varying designs are horizontally compared to meet the demand of revolution to change the energy supplying model in the future.

Firstly of all, it should be pointed out that, what in this article introduced are merely researching results and speculations at the preliminary stage. The researching background is a part of the Sino-Dutch joint project “Modeling Research on User Behavior with Urban Solar Energy Equipment Transformation”, which has been just launched. In the future study, a series of “energy converting parameters” to match divers collecting units, whose measurement will be conducted jointly by a building integrated PV (BIPV) team and our team, are being implemented to apply in different building types and installing basal plane of solar energy units and to convert the acquired solar energy quantity to the actual collection amount with better accuracy. The rate of interval between installation and maintenance is wished to be integrated in the calculation process with this parameter. Secondary, more detailed data of installation and maintenance can be acquired with our cooperating companies to make it possible to perform the comparison among variety of solar energy equipment installing plans in one city. Furthermore, the calculation of stationary accumulated values will be expanded into real-time dynamic data, the representation of which uses the combination of photovoltaic and photothermal conversions with different energy storage capacities. At last, the calculating results of dynamic solar energy collecting ability will conduct a match-test with the dynamic energy consuming prediction, the outcome from another subproject, to figure out the output energy load curve in a district and to check the reasonability of the urban design in view of renewable energy.

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