URBAN ACCEPTABILITY OF BUILDING INTEGRATED SOLAR SYSTEMS: LESO-QSV APPROACH

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Abstract

The concern for sustainable development issues together with the new EU promotion policies are finally leading to a widespread use of Photovoltaic and Solar Thermal systems in buildings. This upcoming reality is opening a new debate on the urban/architectural acceptability of such systems.

In Switzerland the matter has been regulated from 2008 by the art.18-a/LAT, stating that all "carefully integrated" solar systems not attempting to the cultural or natural heritage are accepted. But this text remains ambiguous, and is differently interpreted by solar pros, building heritage administrators and city planners, actually leading to unfair decisions [1].

The presented method aims to bring objectivity to the debate, and to help dealing with the law's two concerns: support the solar spread and preserve the urban context quality, i.e. ensure that the installed systems have an acceptable integration quality for their given environment.

To assess valid and objective acceptability criteria, a few key questions must be answered :

Can architectural integration quality be objectively defined? Can it be somehow quantified, and on which bases? And finally, what are the acceptability factors, and how do they interact with each other?

The method faces all these questions, starting from an objective and clear definition of architectural integration quality coming from recent studies

On the basis of this given definition, a list of solar system characteristics having an impact on the architectural quality is established [4][6]. The detailed evaluation of each of these characteristics in relation to the whole building design leads to a comprehensive and objective quality evaluation, summarized in a "grade" after carefully balancing the impact of each aspect.

Finally a table of acceptability conditions is established on the basis of three variable local factors:

- *Urban context sensitivity* (the quality of the architectural environment);
- *System visibility* (close and remote visibility of the proposed system);
- *Socio-political context* (political and energetic priorities specific to place and time).

One major advantage of the method is its clarity, coming mainly from the separation of the two phases needed for the decision making process:

- On one hand there is the definition and analysis of the architectural quality, carried on the sole base of architectural criteria.
- On the other hand there is the assessment of the acceptability levels, variable according to specified local factors, and to be fixed by the local authorities according to the socio-political context and energetic needs.

1. Introduction

The upcoming generalized spreading of active solar systems in buildings coming with the new EU promotion policies is going to have a major impact on the urban aesthetic (Fig.1).

Fig. 1: Current Photovoltaic and solar thermal systems integrations on building roofs.

The debate on the acceptability of these new systems is hence open, rising hot discussions between the different involved parties. On one side "solar pros", concerned by the urgency of maximizing renewable energies use, ask for a total installation freedom; on the other side, city planners and building heritage institutions express their worries on the urban impact of such systems and ask to restrict their use to certain urban contexts only.

De facto both wills of maximizing solar energy spread and protecting the architectural quality of the built environment are justified, and both should possibly be satisfied at the same time.

In Switzerland the matter has been regulated since 2008 by art.18-a/LAT stating that all "carefully integrated" solar systems not attempting to the cultural or natural heritage are accepted. No more details or specifications are given, so that the text remains ambiguous and is differently interpreted by solar professionals, building heritage administrators, city planners and local authorities, presently leading to iniquitous applications [1]. The debate has reached the media, and the public opinion is also starting to be divided between "pro solar" and "pro heritage".

Nevertheless the aim of the law is clearly double: supporting solar spread in Switzerland and protecting the quality of the urban context, i.e. ensuring an acceptable quality to the integrations.

Starting from that, the question is no longer to be pro or contra, but becomes rather to state what is the minimal level of architectural integration quality to be locally requested

Giving an objective answer to this question, based on commonly agreed criteria is urgent, not only in Switzerland but in Europe in general, as testified by a recent French study highlighting unjustified inequalities in regional PV integration acceptance rates in 2010 (rejection rates varying from 6% in Seine-Maritime up to 85% in Hérault!) (fig.2) [2].

Department	Share of positive answers [%]	Number of analysed cases
Hérault	15%	81
Bas-Rhin	29%	135
Côte-d'Or	53%	110
Haut-Rhin	67%	66
Gironde	77%	70
Seine-et-Marne	78%	85
Seine-Maritime	94%	83

Fig. 2: Comparison of the different PV integration acceptance rates in different French departments in 2010.

2. The LESO QSV method

The LESO-QSV method aims at giving clear and objective answers in this debate. First it clarifies the notion of architectural integration quality and proposes a simple quality evaluation method. Then it proposes a table of acceptability level-s resulting from the combination of different key local factors:
Urban context sensitivity / System visibility / Socio political context and energy situation.

2.1 Defining architectural integration quality

Recent studies have defined building integration quality of solar systems as the result of a good functional/constructive integration in the building envelope (roof or façade) combined with a controlled formal integration in the building design (aesthetic) [3][4][5][6].
The first aspect (constructive/functional integration) is more technical and appears more objective than the second one (formal integration/aesthetics). For this reason the physical integration into the envelope layers is often -and wrongly- taken as the sole criteria to make a distinction between building "integrated" and "non integrated" solar systems. This is often the case for instance in the allocations of photovoltaic's incentives, much higher for "envelope integrated" systems. The paradox is that this need to distinguish between "integrated" and "non integrated" comes actually from the concern of ensuring a certain aesthetics to the urban context, a goal de facto abandoned by this approach, by fear of lacking objectivity!

A survey intended to clarify (to objectivise) the question of integration quality was conducted in 2004, proposing to a pool of 200 EU architects, engineers and façade manufacturers to evaluate the architectural quality of ten existing solar systems integrations[7] . The results showed an impressive coherency in architects' appreciations, even despite their different geographic origins and cultures, and highlighted their high level of expectations regarding integration quality (Fig.3).

Fig.3: Results of a European survey conducted in 2004 on the appreciation of solar systems architectural integration quality by different building professionals (appreciations **scale: --; -; +/-; +; ++).**

These results confirmed the existence of implicit criteria leading architectural integration quality.
To receive a positive appreciation, the system has to be coherent with the global building design logic, i.e. has to be thought as an integral part of the architecture:

- The position and dimension of the collector field have to consider the architectural composition of the whole building (not just the related roof of façade).
- The collector visible materials, surface textures and colours have to be coherent with the other building skin materials, colours and textures.
- Module shape and size should coherently interact with the modular rhythm of the roof/façade.
- Modules jointing should also be carefully considered, as specific jointing types underline in different ways the modular grid of the system in relation to the building.

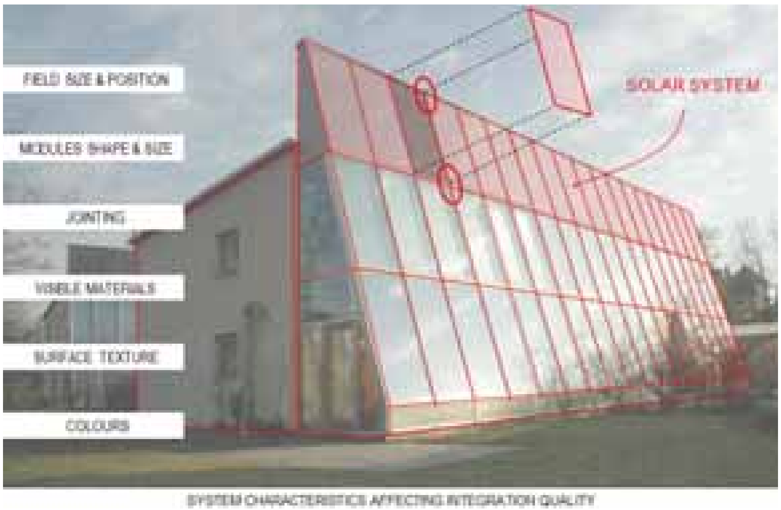

Fig. 4: Solar system characteristics affecting integration quality.

2.2 Quantifying architectural quality

On the basis of these observations it is possible to establish a list of solar system characteristics having an impact on the building aesthetics:
Dimension and position of the collector field / Shape and size of the modules / Jointing types / Visible materials / Surface textures / Colours.

By evaluating in details each of these characteristic in relation to the building, one can get a comprehensive and objective evaluation of the formal integration quality.
The global architectural evaluation of a system quality is then given by the weighted evaluations of all theseelements, including the quality of the constructive/ functional integration into the envelope (called multifunctionality). In the proposed method, for practical applicability reasons, the quality is summarized in a "grade" resulting from the careful weighting of the different aspects (Fig.5). This is a very delicate step,

QUALITY CRITERIA	- (0)	+/- (+5)	+ (+10)	IMPACT FACTOR	BALANCED RATING
MULTIFUNCTIONNALITY				(15%)	
FIELD POSITION / DIMENSION				(15%)	
MATERIAL(S)				(15%)	
COLOUR(S)				(15%)	
SURFACE TEXTURE(S)				(15%)	
MODULE SHAPE AND SIZE				(15%)	
MODULE JOINTING				(10%)	
				fractions to be defined (tot 100%) (+ interdependences to be studied)	FINAL QUALITY RATING (0 to 10)

Fig.5 Proposed quality evaluation tab (impact factors need to be further studied, numbers are given just as examples).

which is still under development. The ongoing work focuses on complementarities and interdependencies between the different characteristics: even if each characteristic is important, some can be deeply entangled with another (colour and texture, material and texture…) and the weighting of the elements must be carefully balanced.

2.3 Setting acceptability levels.

With the quality evaluated on objective bases, it is finally possible to work on acceptability levels.

These are not fixed and are influenced by crossed local factors:

- Urban context sensitivity;
- System visibility;
- Socio political context.

2.3.1 Urban context sensitivity

The first factor influencing quality requirements is the urban context: the higher the quality of the urban context, the higher the required architectural quality for the building integration. The method proposes to categorize the local area in zones of various architectural sensitivities. Three levels are suggested:

- high sensitivity (historical city centres, protected countryside, …, fig 6 a-b)
- medium sensitivity (residential suburbia, …, fig 7a-b)
- low sensitivity (industrial /commercial areas, …, fig 8 a-b)

Fig.6.a: Basel city centre; Fig 6.b: village in UNESCO protected site Lavaux (Switzerland)

Fig.7 a-b: Examples of residential suburbia in Switzerland

Fig. 8 a-b. Examples of typical low quality industrial and commercial environments

2.3.2 System visibility

The second factor influencing quality expectations is the system visibility: the higher the visual impact of the system, the higher the need for a satisfactory aesthetics. For instance a system integrated on a flat roof will be in most cases less visible than a façade integrated system, hence the demanded quality could be lower.

Fig.9: Close visibility of different envelope surfaces in a urban context.

Both close visibility and remote visibility need to be considered (fig www) (fig qqq), as the roofs of a town in the plain will be far less visible than those of a village on a hillside.

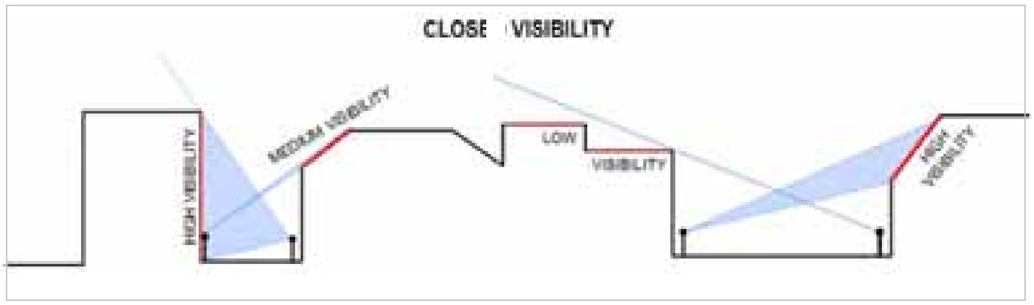

Fig.10: Close visibility of different envelope surfaces.

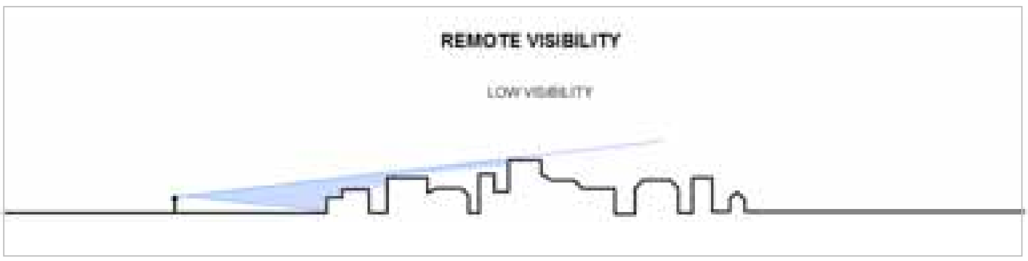

Fig. 11: Low remote visibility example (town in the plain).

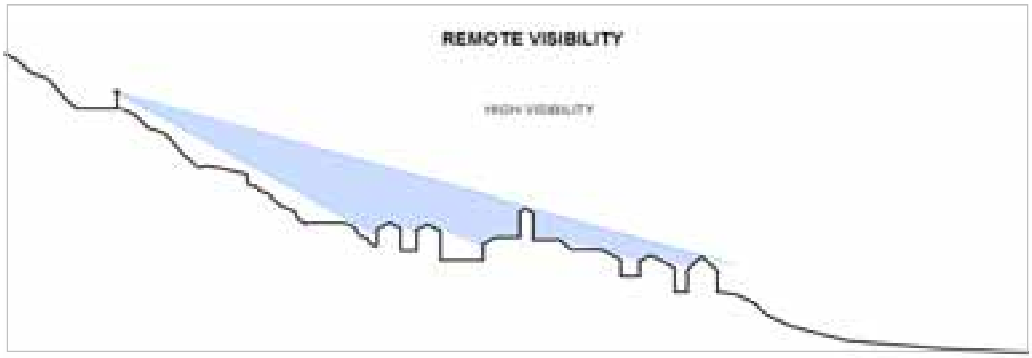

Fig. 12: High remote visibility example (village on a hillside).

Crossing the different levels of context sensitivity with those of system visibility defines a grid of nine different integration situations for which the required quality levels have to be established.

ACCEPTABILITY GRID		ZONE SENSIBILITY		
		LOW	MEDIUM	HIGH
FIELD VISIBILITY	LOW			
	MEDIUM			
	HIGH			

Fig.13: Proposed acceptability grid resulting from the crossing of zone sensitivity and system visibility

2.3.3 Socio political context

Positioning the bar of minimum quality levels for the different local situations is the role of authorities, and these levels will depend on socio-political context and energetic needs specific to place and time (Fig.14 and Fig. 15).

ACCEPTABILITY GRID		ZONE SENSIBILITY		
		LOW	MEDIUM	HIGH
FIELD VISIBILITY	LOW	0	1.5	3.5
	MEDIUM	1.5	3.5	6
	HIGH	3.5	6	9

Fig.14: Example of very restrictive integration quality acceptance values

ACCEPTABILITY GRID		ZONE SENSIBILITY		
		LOW	MEDIUM	HIGH
FIELD VISIBILITY	LOW	2.5	5	7.5
	MEDIUM	5	7.5	9
	HIGH	7.5	9	10

Fig.14: Example of more permissive integration quality acceptance values

If needed and if the global conditions are changing, a simple adaptation of the grid values to these new elements is always possible, without changing the method nor re-evaluating the zones and visibilities.

3. Conclusion

A generalized and unregulated spread of solar systems on buildings could easily result in a damaging rejection by the public opinion, like what happened for instance to the once flourishing parabolic antennas, yet much smaller than solar systems at the building scale (Fig.15).

Fig. 15: Parabolic antennas on historical building facades in France.

The presented work aims to reconcile two "a priori" diverging interests: widely spreading active solar systems on buildings and protecting the architectural environment.
It sets the bases for an objective architectural integration quality assessment, minimizing the effects of subjective interpretations.
The separation of the decision making process into two phases, with different actors, brings clarity to the debate:
On one hand the analysis of the integration quality is based only on architectural criteria, and is not affected by the socio-political context nor local needs.
On the other hand the acceptability levels are conceived to be precisely adapted to the specific local conditions, and are let to the final appreciation of the local authorities.

Having clearly defined levels of required quality for the specific local situations should finally help installers propose adapted solutions (fig. 16-b).
It should also simplify the work of the local authorities, giving them a professional environment and asking only for limited work concerning their own zoning and quality expectations.

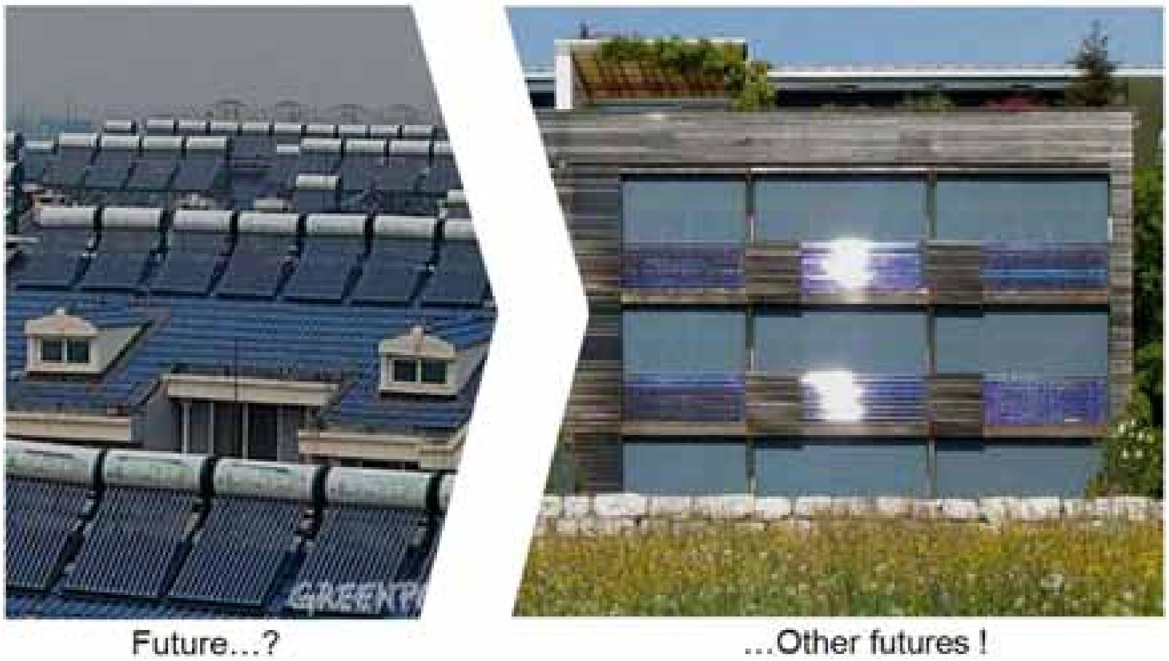

Fig.16-a (left): example of "wild" roof integrations of vacuum tubes solar collectors; ; Fig.16-b (right): example of architectural integration of vacuum tubes solar collectors as balcony fence in a residential building in Zurich (arch. Beat Kaempfen).

With this procedure, there will no longer be "taboo" areas, but only adapted quality requirements, and even the most sensitive areas will be eligible if the quality is satisfactory (Fig. 17).

Fig.17 a-b: Exemplary architectural integration of a wide photovoltaic system on an extremely sensitive urban context: Vatican, the Pier Luigi Nervi's Aula.

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