Deliverable 4.2

Aesthetic Recommendations for Blades and Methodology

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Executive Summary

The receiving environment (host building and visual context/background) into which a new urban wind turbine is to be introduced is the single most important aspect to be considered in improving how well they do or can be made to fit into their surroundings.

Methods to study and understand the visual background do exist and can be borrowed from other disciplines to assist this process. The aesthetics of the turbines and blades themselves and opportunities to improve their aesthetics depend on many factors. Their size, form, scale and texture are all interdependent factors in. Various approaches from disguising, to accentuating, from making a turbine an icon (accepting its prominence and making that a positive aspect) to arranging the required wind generation capacity into a number of turbines such that a rhythm can be created, exist.

Architectural integration is an important means of achieving visual acceptance.

In considering how best to select, locate, size and specify an urban or peri urban wind turbine there are many often competing (but some complimentary) that have to be borne in mind. A pathway through these is suggested in this document.

Abbreviation list

	Description
SWT	Small wind turbine
WT	Wind turbine
VA	Vertical axis (turbine)
HAWT	Horizontal axis wind turbine
AI	Architectural integration

1 Introduction

Aesthetic aspects of the wind turbine is a key issue for social acceptance and thus, for the successful integration of SWTs into urban areas. This document sets out the results of work done to explore and devise an aesthetic framework for the integration of such devices into the urban context. It seeks to define the parameters and boundary conditions that must be understood and adhered to if improving aesthetic integration and thus social acceptance of urban and peri-urban SWTs is to be achieved.

Blades represent the most visually dominant element of small wind turbines and successful integration of them into the overall building design whether in new building or in a retrofit situation is a taxing aesthetic and thus social challenge.

2 Scope

The studies which feed into this deliverable had a defined scope.

Emphasis was placed on the potentials and considerations for the potential emergence and evolution of new blades innovations and how these might be more successful in leading to increased uptake and installation of urban wind turbines.

The scope included improving the analysis practices, decision making procedures and turbine/blade functionalities of new blade development.

The scope was considered to cover how shafts and turbines relate to host buildings/sites (at a foreground level / close up scale) of different type, shapes, constructions including constructional integration and installation/anchorage methods.

Given the illogicality of considering blades totally in isolation from shafts and the two together (as the turbine) in isolation from the host building, and it from its context, the scope was also deemed to include, though to a less or extent, how blade (and shaft) improvements could contribute to better relationship between SWTs and urban areas. This will be covered in outline only as these aspects are developed in a more detail in WP6 and related deliverables (D6.4).

3 Objectives

The objectives of the present report are set out in the DoW and comprise the following;

- To assess the aesthetical impact of turbine blades and investigate opportunities that aesthetic improvements in design could bring about for integrating them into urban districts.

- To provide an aesthetic framework for the integration of turbine blades into the urban context.

- To develop analysis considerations and design/selection guidelines for blade development such that they will be more suitable for acceptable integration into SWTs on buildings.

4 Aesthetic Impact and Framework

It is counterproductive to consider wind turbine blades in isolation from shafts as together these (along obviously with other components) comprise the wind turbine in and of itself. Also given the stated objectives (improving reaction to urban SWTs), it would be inconsistent to limit the field of study to the turbine (elements) without broadening it to address how turbines meet the various parts of their buildings and their immediate sites.

The aesthetic impact of urban SWTs comprises the physical appearance/presence (and movement) of the blades, the appearance/presence of the shaft / other components, their architectural integration (or not) and the connection to the immediate site and streetscape.

4.1 Receiving Environment

The reality of urban wind turbine is that they are physical impositions in a pre-existing visual and aural environment. This receiving environment is the background against which any wind turbine is seen, experienced and adjudicated upon. In European towns and cities there is a vast spectrum visual environments. These range from highly controlled and ordered historic city quarters where no extraneous installations can be erected on a building to more mixed and organic areas. While in the former the visual experience is homogenous and static, mixed 'general' areas (including suburban) has a varied and perhaps chaotic visual environment comprised of walls and planes of buildings, wires (of many kinds), signs, chimneys, flues, antennae, satellite dished and mobile phone transmitters. In general the dominant receiving environment and thus the visual context for WTs in urban areas will be what architects term the roofscape, that area above eye level populated by eaves, verges, ridges of roofs, antennae, chimneys etc.

4.1.1 Characterising The Background.

By any analysis, the visual background of urban wind turbines is of course the urban context, particularly the higher levels where building meets wind and thus (usually) the sky. An examination of this receiving (visual) environment most focus on the different roof elements present in typical European cityscapes has been performed. We carried out such a study as a way to consider what elements are, or have become more acceptable, to city users, their shape, texture, patterns and frequency. The objective was to consider whether potential exists to associate new urban wind turbines with such pre-established architectural 'furniture'. Many of these reference elements are of course to be found in roof architecture. A sample of them is as follows;

1. Air conditioning machines
2. Antennae
3. Sunshades
4. Louvers
5. Chimneys
6. PV and solar thermal installations
7. Dormers
8. Extra structures (ads)
9. Cables
10. Roof lights

Blades and even turbines when static may take some cues form and recede into the background of antennae and aerials depending on the viewpoint and background (sky or building). However, when rotating it is difficult to find any precedent components that can help disguise them.

Other aspects of the receiving environment such as colour of the background (sky and buildings) have been considered below.

Figure 1. Streets clutter and furniture.

Lessons from Backclothing

Backclothing is the term used in landscape architecture to describe the study of visual relationships of objects (wind turbines in our case) and a continuous background (typically for large rural wind turbines the sky or hills). We can take lessons from this emerging discipline to understand the visual experience of urban wind turbines also.

The various factors that influence the effects of backclothing are: visibility and perception of an object, distinction of an object by contrast and varying influences on contrast [1].

Detection of objects depends on contrast between an object and its background [1]. Shang and Bishop on considering detection of an object in different landscape types found that detection was highest in landscapes where "…the object is brighter (positive contrast) than its background", rather than where the object is darker (negative contrast). When detection rates were plotted against object size, they found that "it was much easier to detect, in similar conditions and for these sizes, a bright object on a dark background than a dark object on a bright background" [2].

Figure 2.- SWTs against a busy backcloth.

4.1.2 Visual Context Analysis

Analysis of the visual context of an urban SWT should be a methodical and systematic process and would best be based on principles of Impact Assessment (or VIA) where visual impacts (defined as a change in the appearance of the landscape as a result of development) [3] are studied for intervisibility, fields of visual affect, viewpoints, close and far viewsheds, etc.

In the case of SWTs in an urban environment, particular care must be given to not only pater and colour of buildings, but also shape and form of adjacent extraneous elements such as satellite dishes, chimney cowls and vents, etc.

Practise is established the viewpoints and zones of influence of a development, to study the background and to generate actual before and predictive (simulated) after images of the development. Ideally, and in normal practise different options including a 'do nothing' scenario are considered and the least intrusive option is accepted and implemented.

The following question could form the basis of a visual context analysis for SWTs in a peri urban environment:

- Has a formal visual assessment of the nearby built context been carried out?
- What is the scale of the built context?
- Does the proposal relate well to this?
- Have 'view-in' points been identified and ranked (most sensitive/ significant to least sensitive)?
- Is the visual landscape calm or busy?
- Will the turbine presence and blade movement of the proposed turbine(s) change this?
- Is the visual landscape simple and ordered or complex and diverse? Will the outline presence of the turbine confuse or undermine these qualities?
- Does the introduction of the turbines create local landscape "clutter", especially where previous turbines of different designs or where other urban building 'furniture' (antennae, satellite dishes) would now co-exist?
- Could blades/ turbine(s) with the same form as the previous turbines or as nearby building furniture used?

4.2 Blades and Shafts

The following aspects of turbine blades were scoped as the ones that raise most questions around aesthetics in a built environment.

Table 1. Applicability of design variables to different WTs.

Issue / Opportunity	Horizontal Shaft WTs	Vertical WTs
1. Blade colour	Y	N
2. Turbine colour	Y	Y
3. Blade specularity	Y	N
4. Turbine Rhythm	Y	Y
5. Blade quantity	Y	N
6. Blade geometry	Y	N
7. Architectural Integration	Y	Y

Urban landscape colours, turbine elements design, rhythm in buildings and other parameters were analysed next, as well as the possible design changes when implementing wind turbines in a specific urban context.

4.2.1 Blade Colour and Specularity

Whilst larger commercial turbines are generally light grey in colour to reduce their contrast with the sky, there may be greater scope to carefully consider [4] use of other colours of small scale turbines which will reduce their prominence.

Our study carried out an analysis of a representative sample of photographs of European streetscapes/ buildings and urban skies to explore what typical colours are represented in the receiving background of potential urban SWTs. We derived the following sample typical palettes for the various sectors/ slices of the receiving environment backdrops.

Figure 3 Typical Colours in European Urban Skies (daytime)

Figure 4 Typical Colours in European Urban Roofscapes

Figure 5 Typical Colours in Foreground (streetscapes) of European cities.

Colour studies suggest that, where small wind turbine are located in urban situations (with lower elevation, non-skylines, more enclosed visual fields), there could be scope to relate the turbines to the backdrop pattern and tones using colour, i.e., to use a darker or more distinctive colour than for rural turbines.

In locations where small turbines are predominantly viewed against the skyline (i.e. where they break the distinction between built form and open sky), the above samples indicate that and therefore a paler colour may be appropriate.

In all cases reflectivity of the turbine components should be minimised and a variety of seasons and weather conditions should be considered when choosing turbine colour [4].

Care needs to be taken with differing tower/blade colouring. For example, darker turbine heads can look as if they are floating in situations where a light turbine base is seen against the sky. Conversely lighter turbine heads can disappear in bright conditions, leaving the darker tower with no clear rationale for being there.

4.2.2 Blade & Shaft Characteristics

In contrast to larger scale commercial wind turbines, according to Scottish Natural Heritage [4], a greater variety of styles, designs and colours of small turbine are commonly available, generally with faster rotation speeds. They report that choice of turbine is a key factor in the visual suitability of small turbines at any site, especially where cumulative effects may occur. Careful choice of turbine at an early stage in the design process will help to ensure an improved fit and avoid complex visual mixes of turbine types and other elements in an urban or any location. Even though these are considerably smaller than commercial turbines, SWTs have the potential to be taller than buildings (even sizeable farm buildings) and mature trees.

There are two main operational forms of small turbine currently available – those which rotate on a horizontal axis and those which rotate on a vertical axis.

Horizontal Shaft SWTs

The most common SWTs are three bladed horizontal axis machines mounted on a tubular tower attached to or adjacent to a building. Two bladed machines however are not uncommon. Some

small scale horizontal axis turbines have yaw arms (to orientate them to the wind) which can be as visible as the turbine blades themselves. Five bladed models, on one model connected [5] by a hoop or ring, also exist.

These aspects and conflicts could be a particular consideration when 2 bladed turbines are viewed in combination with 3 bladed models

Figure 6. A range of blade arrangements on HzWTs.

Vertical Axis SWTs

Historically, these turbines are categorised as Savonius or Darrieus types, according to the principle used to capture the wind flow. For the Savonius type, the wind pushes the blades, which implies that the rotation speed is always lower than the wind speed. Contrary to that, the shape of the rotor of the Darrieus type makes it possible for the rotor to spin faster than the wind speed [6].

Figure 7. Savonius type vertical axis turbine.

Vertical Axis Wind Turbines tend not to be as efficient [4] as the more common horizontal axis machines, but they do offer benefits in low wind situations. They also tend to be easier to build, can be mounted close to the ground, and handle turbulence much better. However, the variation in wind loading on blades during revolution causes more fatigue and therefore wear and tear, and in some cases guy wires may be needed to ensure stability. They are generally smaller than horizontal axis turbines and tend to be more common in urban areas where there are townscape issues to consider (such as their scale in relation to their setting, effects of wind tunnelling and resultant turbulence and acoustic concerns). Their forms are more often specially tailored to create a design statement for individual sites.

CrossFlow and Other Turbines

A myriad of other turbine types exist. Many of these come close to crossing into the field of architecture per se for the reason of improving their aesthetic acceptability while adapting to urban wind conditions.

Figure 8. Energy ball and wind wall turbines.

Framed and Hooded Turbines

There are also many turbines and blade arrangements that are not fully described by the above categorizations. Pole mounted tubes that contain rotating fan turbines are one such recent innovation. These reportedly improve airflow (cutting noise and vibration) and are less sensitive to wind direction fluctuations.

There main aesthetics advantage however is that they look more architectural and even sculptural than conventional turbines do.

Figure 9. Turbine as solid cylinder.

4.2.3 Blades and Motion

Visual Experience of Blade Rotation

The movement patterns of turbine blades is also thought to increase prominence [1], as described by The University of Newcastle [7] who states “the movement of the blades (of a wind turbine), in all cases where this is visible, increases the visual effect of the turbines because this tends to draw the eye”. Research reveals that wind turbine blade movement is more noticeable when seen in high contrast, and the University of Newcastle (2002) states that movement is “… more perceptible when backdropped against dark vegetation compared to grey sky”. Bishop and Miller [8] reveal too that “…the difference between still and moving effect gets greater as the turbines become increasing prominent (either closer or with higher contrast)”.

However, some contradictory responses have been obtained from perception studies; for example, it was found in one study [8] that “the negative visual effects when turbines had moving blades were consistently lower than when the blades were stationary”. Bishop and Miller suggest two possible explanations: one, that people prefer to see wind turbines ‘working’ as they feel “when stationary they are an intrusion with no evident purpose”, and two, that moving wind turbine blades relate better to a landscape if this is evidently ‘windy’. There may also be an additional reason; if stationary, the varying blade positions of different wind turbines within a particular development can increase the apparent complexity and incongruity of a windfarm image within a simple landscape. This is in contrast to when all the wind turbine blades are rotating, when differences in blade position tend to be difficult to discern as it is not easy to focus upon more than one machine at a time.

Blade Quantity - Affects on Perception

Experience and research suggest that significant differences in how HAWTS are perceived by the eye emerge from whether the turbines have 2 or more blades. Two blade turbines are more calm and poised when stationery and tend to have longer aircraft–like blades whose rotational movement is commonly perceived [1] as regular, which is a positive, but less smooth (than 3 bladed models) from some aspects.

Figure 10. Different visual experiences of blade motion.

4.2.4 Turbine Quantity and Rhythm

Our own studies and experiments suggest that there may be merit paradoxically to having to a number of turbines instead of one. Having more than one (ideally 3 or more) establishes a pattern and rhythm.

Figure 11. Studies exploring variation in rhythm, of SWT blades.

Figure 12. Studies exploring variation, number and texture of SWT blades.

This affords the opportunity in an urban environment to link the turbine positions to architecturally repetitive elements, and prevent them standing out as much as single turbines might.

4.3 Anchorages

Anchorages both the structural connection and tethering cables are often an integral part of a small wind turbine essential component.

Various studies of these were carried out and it was concluded that such components generally do not comprise a significant aesthetic imposition on the majority of SWTs in urban areas. The reasons for this are that most urban and peri urban SWTs are installed on buildings rather than as free standing elements. Where this is the case, the viewers are by definition at some distance from the turbines. At distances of more than 20m (a 3 to 4 storey building with viewer set back from its perimeter) will mean the presence of cables diminishes to almost imperceptibility (except perhaps against a clear sky). It is also noteworthy that most types of wind turbines do not require cables or guys.

4.4 Architectural Integration

The most powerful means of achieving aesthetic acceptance of SWT is to reduce their appearance to being part of the background. This can be done either by making them 'read' as part of a busy visible (i.e. not too distant) background or by architecturally integrating them into the foreground (i.e. effect the building itself) as seen from the viewers point of view. This second approach is what we term architectural integration. It involves designing in (or adding if the installation is a retrofit) additional planes, walls, roofs, hoods or tubes that seem part of the buildings core composition and which can visually 'absorb' the turbines so them also seem part of the composition and design.

4.4.1 Examples From Pilot Site 1 – Choczewo

Another aspect, though it is part of a greater discussion being addressed in WP 6 (T 6.4) is that of how blades relate to turbines and how these relate to buildings. This question of architectural integration has been investigated in a number of ways, the most useful of which is a study of the turbines to be installed at 2 of the 3 SWIP pilot sites.

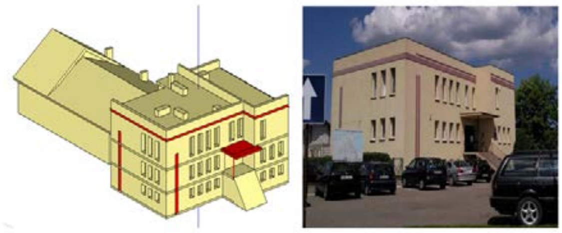

Figure 13. The host building at Choczewo.

A horizontal axis cross flow turbine was chosen for this pilot site. The decision was taken to use the opportunity to create an architecturally integrated solution. While the design of new buildings presents the designers with a wide variety of integration opportunities, solutions are more limited where SWTs are to be added to an existing building, as is the situation at Choczewo.

The existing context (from a wind and urban morphology point of view) and building was studied and the position with most wind access was identified. The building is three storey tall and the part which is to receive the SWT has flat roofs and parapets as its main architectural expression.

Holes, Planes and Frames

The images below illustrate the process of adaptation and optimisation of the chosen turbine type to the actual building and its structure in connection to the local winds directions and numerous other parameters.

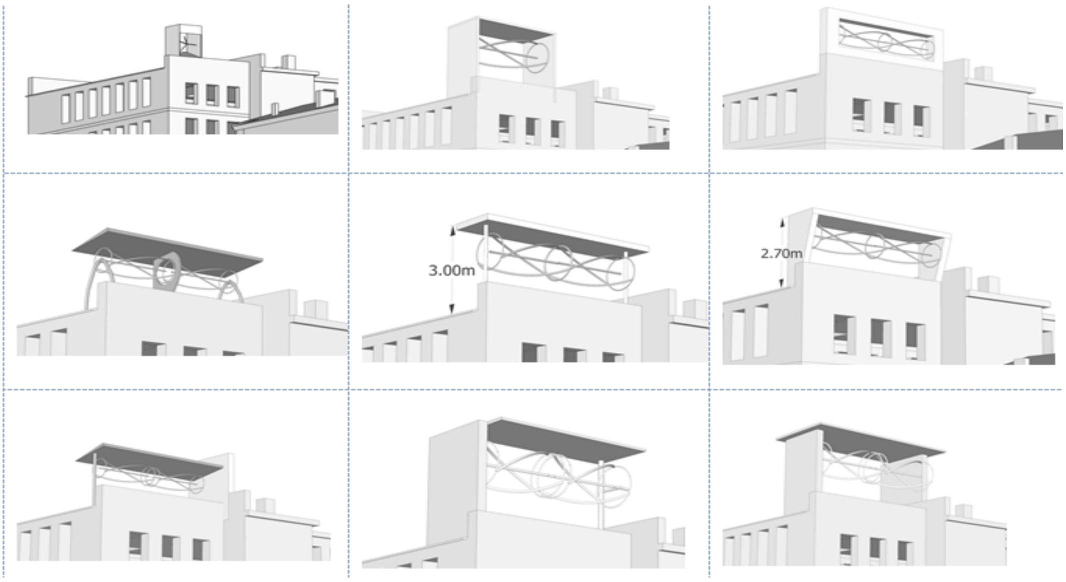

Figure 14. Examples of architectural integration at pilot site 1 Choczewo.

Many studies of how best to extend the planes of the building to make the new turbine appear to be inserted into the facades of the building rather than sitting on it, without compromising the wind access and energy production, were made. Various combination of creating over-planes, side planes, planes and posts, tunnels, one sided tunnels, etc were created and considered.

Many of these approaches make use of the Venturi effect to turn the challenge of architectural integration into a further advantage (including the airflow through the turbine due to the architectural elements).

4.4.2 Other Architectural Integration (AI)

There are many other examples of AI form creating frieze at roof line under which turbine(s) sit, creating a hole or dip in the roof to funnel air and disguise the location or of building a special ridge disguised as a long vent.

Figure 15. Other examples of architectural integration of SWTs.

More dramatic approaches where the entire buildings form has been set up to accommodate turbines are also possible.

Figure 16. AI through adjusting the entire form of the building.

4.5 Blade and Turbine Refinements

4.5.1 Horizontal Shaft –Pilot Site 3 – Zaragoza

A horizontal shaft turbine was proposed for the new CIRCE building at Zaragoza.

While this building is not yet constructed, its final design had been collected before the SWIP project started.

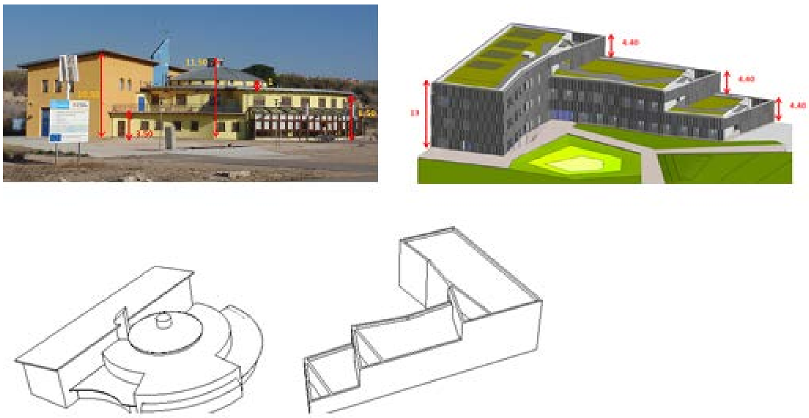

Figure 17. Zaragoza host building.

As with Choczewo, the wind and urban form of the existing site context including buildings was studied and a favourable position was identified.

4.5.2 Blade Enhancement

The first explorations involved attempting to merge three blade HAWTs with oversized fixed and rotating planes which would be coloured to appear as part of the architecture of the building

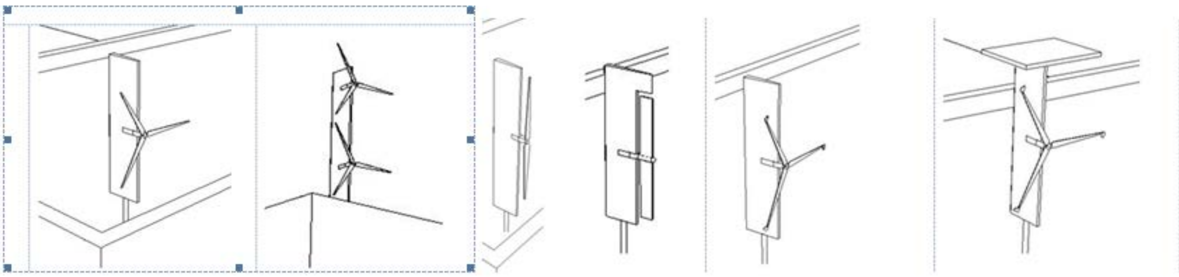

Figure 18. AI explorations and options for HAWT at Zaragoza.

Various solutions and sculptural possibilities were explored.

The process started with an examination of the host buildings. These had been modeled for an earlier task (WP2) and those computer models were developed and detail of the building architectural form and context added. Critical viewpoints were identified by studying the extended townscape, topography and background. The buildings geometry was evaluated and the dominant architectural form identified.

Design exploration were then made as to how to either remake the turbine so some of their components appeared to be part of the architecture itself or to 'house' the new turbines within planes and aperture in the buildings form so that the ensemble appeared to grow from the architecture. In the first approach (at Zaragoza) shown above and discussed further below, the turbine shaft was re considered as if it could be a long vertical planes rather than a mast or pole. In the second approach at Chocezewo (Fig 14 above) we manipulated key planes in the host building, extending mirroring (i.e. duplicating) and 'exaggerating' these forms so that they both funneled the airflow and provided support to the turbine – with the same architectural intervention.

4.5.3 Geometric Manipulation

Following this another approach was undertaken, that of taking particular part of the blades and manipulating them to become reminiscent of more architectural forms.

Here the ring becomes a cylinder and then tube.

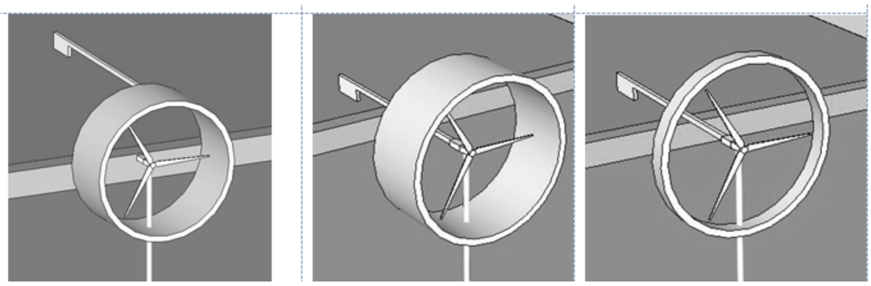

Figure 19. AI explorations of VA WT.

Another approach the adjustment of the tail to become more like a planar element, a still flag, was attempted.

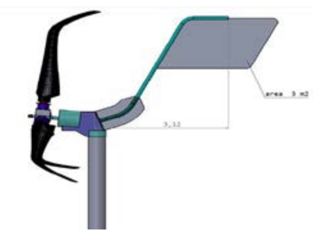

Figure 20. AI by modifying the tail

5 Aesthetic Recommendations –Methodology for Selection

5.1 Aspects to be Considered

It was considered beneficial to assimilate the knowledge set out above into one comprehensive guidance matrix. The table below sets out the aspects deemed necessary to examine and consider.

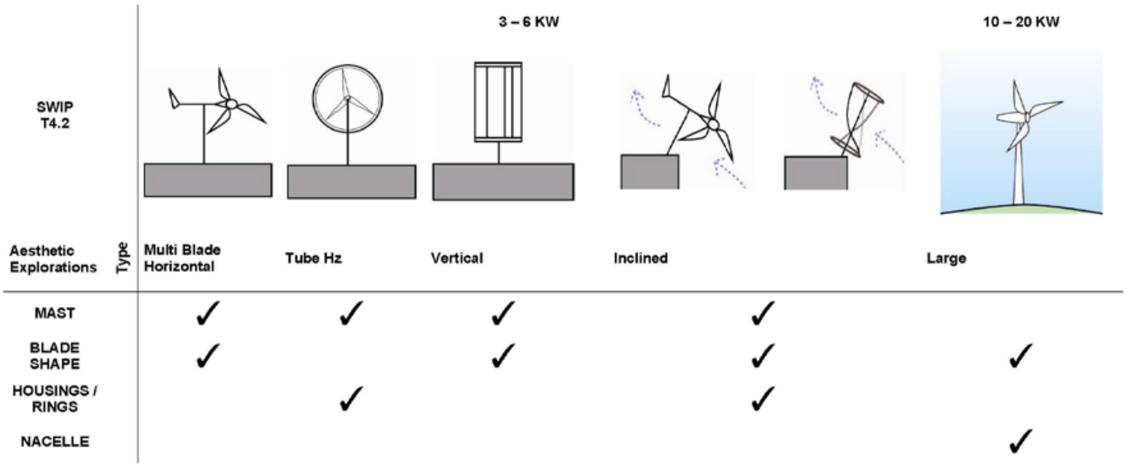

Figure 21. Scope of aesthetic considerations around blades.

5.2 Selection Consideration Framework

The following table attempts to summarize and interrelate the consideration, conflicts and overlaps inherent to installing new turbines in urban and peri-urban areas. It is based on previously published guidance [9] for small scale turbines in more general areas and adds in many of the observations and lessons explored above.

Table 2. Blade aesthetic selection framework and methodology.

Variables	Guidance/ Considerations	Action (If Yes)
Priority	Is maximization of energy output (and adaptability to wind direction) more important that aesthetic and social acceptability?	Consider using standard 3 blade horizontal vertical shaft turbines
	Is the appearance of the blades when stationary more important than when rotating?	Consider a 2 bladed vertical shaft turbine
	Is an being iconic or sculptural or the desire to express renewables as a symbolic statement important?	Consider a vertical shaft turbine.
	Is the building new and still under design or if an existing building, can roof and high	Integrate the turbine in the buildings architectural elements.

		level walls, planes etc. be design to incorporate the turbines ?	
	Relationship with Settlement	Do the proposed turbines respect the scale of adjacent buildings?	Consider reducing the size of the SWTs
		Does the proposal have a logical visual relationship with relation the settlement pattern?	Consider moving the position of or providing a number of SWTs in a positive relationship (number, size, spacing)
		Will the turbines dominate approaches to settlement?	
		Have the turbines been sited to minimize impact on people who live in, work in, travel through the locality or use the area for recreation?	
	Context Characteristics-Medium scale	Has a visual assessment of the nearby built context been carried out?	Carry out a VIA
		What is the scale of the built context? Does the proposal relate well to this?	Examine local context and see if blades with similar scale and shapes could be used
		Could blades/ turbine(s) with the same form as any previous turbines or as nearby building furniture be used?	
		Have 'view-in' points been identified and ranked (most sensitive/ significant to leas sensitive)?	Consider moving the turbines to locations with less views in
		Is the visual landscape calm or busy? Will the turbine presence and blade movement of the proposed turbine(s) change this?	Consider Architectural integration of the turbines
		Is the visual landscape simple and ordered or complex and diverse? Include consideration of confusion and clutter and affect of previous turbines (of different designs) and other urban building 'furniture' (antennae, satellite dishes) that could occur in the analysis?	Consider Architectural integration of the turbines
	Micro context	Are the proposed turbines similar in form, colour and scale to forms and shapes (building 'furniture') already existing in the locality?	Consider adjusting form and colour of the blades and shafts.
		Have key built landscape characteristics (geometries, materials, landscape & built elements, been identified? Do the proposed blades/turbines relate well to and not dominate these aspects?	
		Does the proposal follow patterns (spacing, scaling and locating) of small-scale shapes and forms on/near buildings (building 'furniture') in the area?	Consider moving and respacing the turbines
	Focal Features	Will the proposed turbine(s) introduce a new focal shape/element that creates visual confusion or competes with other	

		notable features?	
		Does the proposal interrupt views to or from existing focal features? Have opportunities to create a new sculptural image been maximised, especially in heavily modified or designed landscapes?	
	Rotation Speed	Have the relationship between any differing blade movement speeds (between 2 types of turbines/blade arrangements in this proposal or between these proposed turbines and previous nearby ones) been considered? Can any potential for contrast be minimised?	Minimise contrast between different movement patterns of new and existing turbines
	Turbine/Blade Type	Have a range of different turbine type and blade shapes and numbers been considered in relation to the building and context? Do the proposed turbines have the most appropriate form, appearance and blade movement for the proposed site?	Consider all type of turbines?
	Turbine/ Blade Quantity and Rhythm	Is, or could the proposal be for more than one turbine?	Consider varying the type, number, spacing of the blades/turbines to reduce visual clutter and confusion, or create a sense of rhythm or architectural integration while providing the same energy?
	Turbine/Blade Colour	What is the relationship between the proposed turbines and nearby building forms and skylines? Are they predominantly seen against the sky or 'backclothed' by buildings or trees? Consider the different seasons, weather and day night differences. ?	Consider colour schemes for the turbines that are more attuned to the backdrop.
	People	What people in the area will be affected;	
		those who see & hear them from afar?	In an urban environment this may not be a problem
		This who see & hear them from nearby This who can only hear?	Consider relocating to be away from openable windows and vents, and from public areas (streets and parks) where people stop.
1		Those who can only see,	Either architecturally integrate or Consider relocating to be away from view windows and vents, or to be seen only against a busy backdrop (form viewing points)

6 Conclusions

How the blades of small wind turbines exist and appear in the built context depends on the receiving environment, the geometry, materiality, form, frequency and relationship to the host building, of the blades. Potential improvements to current practice in selecting, locating, and specifying SWTs are possible and have been identified by studies undertaken in this work and by drawing methodologies in from parallel disciplines. A set of selection Guidelines (considerations and questions) for wind turbine and blade development such that they can more successfully be integrated into buildings, urban districts and other suitable areas is set out.

The Guidelines address both analysis protocols, decision making procedures and turbine/blade functionalities. Also considered are wind turbine/ blade type, building, location (at medium and micro scale) and design integration potentials. The work herein summarized has emerged form and informed the design (and later manufacture) of the SWIP projects SWT prototypes.

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