WICO GuideLines

Policy GuideLines to promote and accelerate the uptake of small wind renewable energy systems in the European Union.

This GuideLine Document is the output of WP4 of the WICO Powerprogramme project (Interreg IVC)

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PREFACE

Aims and Objectives of the Guide

The WICO project is an exercise in cooperation between England, Italy and Spain with its overriding aim to stimulate the wider uptake of small-scale wind turbines through exchange of knowhow and experience between the three countries. The main objective of this guide is to provide a decision-making framework for administrators and politicians who have a direct affect in their local or regional territory on policy design and implementation.

Target audience

The guide is specifically aimed at the following target audience:

- Regional politicians
- Local politicians
- Municipal technical officers
- Local planning officers

However we also hope that it will provide interesting reading for students, teachers, and all citizens that may wish to see a faster development of small-scale wind.

How to use the Guide

This guide is split into several sections. The first is an executive summary of all the conclusions drawn from the experience of the WICO Partners exchange during the two years of the project. The executive summary is mainly aimed at those decision makers who do not need to go too deeply into the details but need some general guidance on how to go forth and make well informed judgements in their respective spheres of influence. The subsequent sections give a more detailed explanation of the current situation in which the small-wind turbine industry finds itself. The work has been split into three main lines of action: Policies, Market, Technical. For each of these headings the main barriers to small-wind applications and their respective policy solutions are expounded along with examples, if existing, of best practice within the three partner countries that has been revealed during the research. This document has been designed to summarise the combined report for work package 2 called “analysis framework” and apply the findings of this more detailed research document to a policy making tool that is clear for readers.

By using this guide and applying the recommendations that are suggested, the WICO project aims to provide positive assistance to help the public sector overcome the barriers identified and ensure a successful future for the small-wind turbine industry.

POWER Low Carbon Economies
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EXECUTIVE SUMMARY

1. Wind Energy has seen huge success in recent years. By 2010, 15 per cent of Spain's electricity demand was met by its installed wind capacity, the UK is in the process of putting into operation the World´s largest offshore wind farm and Italy produced more than 5.5 GWh of wind energy produced last year.

2. Article 4 of the Renewable Energy Directive (2009/28/EC) required Member States to submit national renewable energy action plans. These plans are intended to be roadmaps of how each Member State expects to reach its 2020 targets for the share of renewable energy in their energy mix. Targets for 2020 for the three partner countries in small-wind include 370MW for Spain, the UK does not have specific targets for small-wind energy but plans 2% of its electricity to come from small renewable energy sources, and Italy plans 12 GW of wind turbine power (both big and small). The action plans for the 27 member states can be found at:

http://ec.europa.eu/energy/renewables/transparency_platform/action_plan_en.htm

3. The advantages of small-wind turbines are that it: Provides power to off-grid locations; saves greenhouse gas emissions and other pollutants; enhances the reliability and power quality of the grid; reduces peak power demand; increases national electricity generation; diversifies the country´s energy supply portfolio; makes the electricity supply market more competitive by promoting consumer choice; guarantees to customers a good financial investment where the electricity bill is high or the incentives reliable.

4. In Spain the main issue as things stand is that there is no differentiation in the legislation between small-wind turbine installations and big wind turbine installations. What this means is that the same legal process needs to be followed to obtain permission for a 1 kW turbine as for a wind park of 20 MW. In Italy, there is a differentiation between the two for planning purposes. The UK too has differentiation and the planning procedures are usually quite quick because small-wind specific legislation already exists. Where this distinction between small-wind and large wind is not made serious planning issues can arise for small-wind turbine installations.

5. Feed-in-tariffs are proving to be the most effective way to subsidise renewable energy particularly at the smaller scale. They are an effective way of reducing the payback time for these types of installations. If Feed-in tariffs are not possible then another option is called net metering. This is where the individual can sell all the excess energy to the grid but at the going electricity price. Monetary incentives should be combined with restrictions on the size of the installation and time limits for competent authorities and obligations for connection.

6. The tax burden on individual who wishes to install should be minimised. Ideally all income from small-wind energy it should be tax free. Imposing excessive tax burdens on the electricity producer at this scale works against business and compromises the viability of the installation.

7. One of the main issues identified by the WICO project are administrative deficiencies in practically all countries which create an artificial barrier to smooth processing of small-wind installations. Planning Law should include reference to: the permitted height of the turbine; the length of time to process an application; the limit for turbine capacity; certificates from the installer; certificates for the wind turbine; noise nuisance; flicker issues; social impact; current designated land use category; building regulations.

8. There is a real lack of training and information on small-wind for local and regional municipal officers.

The environmental impacts of a small-wind turbine installation are minimal yet such installations often get confused with larger wind farms due to a lack of knowledge and misperception. Local municipal administrators must know what their respective laws are but at the same time have an understanding of the real issues and real environmental impacts of small-wind installations.

9. The length of time to acquire such permits varies enormously between countries making it one of the key issues to address. In some countries permission must be granted within 8 weeks, and in others delays can last up to two years! Planning permission and permits for grid connection need to be efficient. Insufficient regulation here could compromise safety and quality of the electricity network in the locality or on the other hand, excessive regulation can allow electricity companies to stall the granting of permissions and hence the whole installation procedure.

10. Local or regional guidelines and by-laws are recommended that draw a distinction between the two scales of wind turbines. A vital role that local and regional administrations have to play is that of fast-tracking the administrative procedures for small-wind turbine installations. Such simplification is being considered in the UK by making small-wind turbine installations a "permitted development". Training of key administrative personnel is also vital, as a knowledge gap exists that creates problems for the administration, problems for the developer, and problems for the market. The administrative fee burden on installer or owner should also be minimized. Imposing high administrative charges, fees or taxes, should not be permitted and consistency should be provided at all levels of policy and legislation.

11. It is very difficult to generalize in terms of absolute costs for small-wind installations. Obviously a 50kW turbine will cost significantly more than a 2 kW turbine. It is also misleading to generalize on costs per kW of nominal power, as this can vary from between 1€ per W for the cheapest import to 5€ per W for specialised turbines. Their reference value should really be per kWh: therefore the correct way to compare the costs of small-wind turbines is their total cost (turn-key installation) divided by their production during their life (generally 20 years). In order to be viable, some form of financial incentive is usually necessary to compensate for its comparative expense when compared to conventional sources of energy.

12. Grants help overcome the financial barrier of high up-front initial investment costs, and can give a boost to the financial viability to the project as a whole, as well as providing a "carrot" to any keen individual or investor. However they must be designed so as to ensure that the resultant cost reductions are passed on to the consumer.

13. Feed-in tariffs have proved highly effective means of boosting renewable energy. However, their main disadvantage is that the subsidy is directly passed on to consumers through a higher electricity price. In the case where Feed-in tariffs are not viable, or purely as a simpler alternative for small-wind energy producers, a system of net-metering can be introduced. Low interest loan schemes for individuals to finance small scale renewable installations is another financing option as is Third Party Financing.

14. Wind power is not without its critics and is often victim of a significant degree of negative perceptions. Although not totally founded on myths, these problems are usually highly exagerated, and particularly in the case of small-wind turbines. In terms of visual impact, the relative impact of small-wind turbine installations will be minimal. However, as it is perception that we are dealing with, care must be taken, especially in visually sensitive areas, for example protected areas, ridges etc. Noise is a very delicate issue ruled by norm IEC 61400 that stipulates limits for noise emissions at different wind speeds that wind turbines must meet. The majority of modern small-wind turbines have been designed to respect the IEC 61400 norm and therefore municipal officers must require a noise emission test in order to avoid any problems. If a wind turbine is correctly installed it should have minimal visual impact, not create a noise nuisance and be of no threat to wildlife.

15. Information and awareness campaigns for the general public, politicians and other key decision-makers are recommended. Clear guidelines must be drawn up for planners and all other relevant officers. Consultation with citizens within the local vicinity is a highly recommended procedure that installers, investors or owners should follow. Avoiding development of large miniwind parks is important. Small-scale wind installations can act as an educational tool and as a driver within the local area for more uptake of these types of installations, which local government could undertake.

16. The two main efficiencies usually stated for small-wind turbine are explained: Power Coefficient (Cp) and Capacity Factor (CF). The Cp is the overall efficiency of power conversion ratio, and varies with both rotor and wind turbine components and design. The Capacity Factor, is a commonly used coefficient for representing the annual energy production of a wind turbine installed in a certain site. The real production (measured or evaluated) is divided by the theoretical annual energy production and a percentage is the result. Large wind farms give Capacity Factors around 30%, whereas small-wind turbines, if correctly sited, should give a Capacity Factor of between 10-20%.

17. Although turbines should be designed to last for at least 10 years service and often much more, many do not live long due to technical failures or excessive need for maintenance. They frequently have misleading or non-existent noise data and are not designed according to existing safety standards. Some may even be illegal to use, because they do not fulfil legal product requirements. Choosing a turbine amongst the many manufacturers can therefore be problematic.

18. One of the key factors responsible for the current shaky consumer confidence in small-wind turbines, is the uncertainty with regard to their real energy production. The best way to predict the energy production is based on the wind speed distribution (Weibull curve) and its Power Curve: By multiplying the Weibull curve and the Power Curve we can obtain conclusions on annual energy production for a given site. This is the most accurate way to estimate annual production.

19. The relationship between velocity and power is cubed, which means that if you increase the windspeed by a factor of 2, you can increase your instantaneous power by 8 (2^3). Correct siting is key to success of an installation. The wind turbine should be sited as high as financially or technically possible to maximise windspeed and away from obstacles, being sufficiently out of their wake to avoid turbulence. Where obstacles cannot be avoided, a wind rose can be very useful to determine whether and if so where, a wind turbine should be installed.

20. Most European countries will have an organisation responsible for wind mapping. They provide data and often meteorological tools for calculating mean windspeeds and predominant wind directions, depending on the height of the turbine’s hub. Measurements for at least 6 months with an anemometer for windspeed and wind direction, as well as other climatic conditions is highly recommended.

21. Lowering of the prices of small-wind turbines is one of the main goals which must be obtained. Currently they are relatively expensive compared to the amount of energy they can produce. Some increases in wind turbine efficiencies are to be expected, and depending on the behaviour of demand, cost reductions in the next few years are possible.

22. Insufficient knowledge on small-wind installations and a lack of training available for municipal officers, mean that municipal and regional administrations are not correctly informed on the technology, its performance and its impacts vs benefits. Training is therefore recommended. Planners should require information on: Structure; correct siting; wind direction; obstacles. Furthermore any planning application should require a production estimation from the customer, investor or installer to demonstrate the viability and validity of

the project.

23. Accreditation schemes for wind turbines and installers should be set up by Government, whilst providing assistance and information to assist consumer-choice. Public procurement could also be an option for boosting the sector.

24. Technical advances and improvements are expected in the coming years in the following: Power train; mechanical components; power conversion electronics; control systems; aerodynamics; remote monitoring; battery storage. As the technology is not a mature one, there is still a great scope for technical progress, which coupled with cost reductions could lead to an accelerated uptake for small-wind installations.

25. Installing innovative turbines or innovative applications could provide useful case studies of newer technologies, and could be undertaken by public bodies. Monitoring and national R&D programmes could also provide invaluable information on the performance of small-wind turbines.

SUMMARY OF POLICY INITIATIVES

Nº	Policy Initiative	Level
P1	Legislation that stipulates the difference between small-wind and large wind	National
P2	Introduce a reliable and sustainable system of Feed-in tariffs to promote small-scale wind turbines connected to the grid	National
P3	Accompany Feed-in-tariffs with time limits for competent authorities and obligations for connection	National
P4	Accompany all Feed-in-tariffs and other monetary incentives with restrictions on the size of the installation	National
P5	Allow the possibility of net metering	National
P6	Reduce tax burden on individual who wishes to install	All levels
A1	Develop local by-laws specifically geared for small-wind	Local/Regional
A2	Streamline of bureaucracy specially geared for small-wind	Local/Regional
A3	Fast-track of administrative procedures	Local
A4	Training of key administrative personnel	Local/Regional
A5	Minimize burden of administrative fee on installer or owner	Local
A6	Provide consistency at all levels of policy and legislation	Local/Regional
F1	Provide grants for small-wind turbine installations	Regional
F2	(as P2) Introduce a reliable and sustainable system of Feed-in tariffs to pro-mote small scale wind turbines connected to the grid	National
F3	Facilitate low interest loan schemes for individuals to finance small-scale renewable installations	National
F4	Promote innovative financing mechanisms, like Third Party Financing and Results Purchasing.	Local/Regional
S1	Provide information and awareness campaigns for the general public	Local
S2	Provide information campaigns for politicians and other key decision-makers	Local/Regional
S3	Take preventative measures to avoid feeding misperception- provide clear guidelines	Regional
S4	Consult with citizens within the local vicinity	Local
S5	Avoid large miniwind parks	Regional
S6	Install Educational small-wind installations	Local
D1	Provide basic training for municipal and regional officers in optimizing small-wind performance	Local/Regional
D2	Require production predictions	Local/Regional
D3	Introduce accreditation schemes for turbines	National
D4	Introduce accreditation scheme for installers	Regional
D5	Assist consumer-choice by hosting a website with information on products etc	Regional

Nº	Policy Initiative	Level
D6	Investigate public procurement options for small-wind turbines	Regional
T1	Install innovative designs in municipalities	Local
T2	Invest in ideas- local innovation technology development programmes	Local/Regional
T3	Provide monitoring equipment for existing installations	Local/Regional
T4	National R&D Investment	National

KEY

Letter	Type of Policy Initiative
P	Policy-making
A	Administrative
F	Financial
S	Social
D	Demand-side
T	Technology-based

INTRODUCTION

Background

If 20 years ago you had predicted that globally there would be 160 gigawatts of installed wind turbine capacity you'd probably have been taken for being at best hopelessly optimistic, if not totally deluded. Yet this staggering achievement in so little time continues to surprise and with wind energy now being such a big business, it is predicted that by 2030 a quarter of the world's electricity demand will be met by wind energy. Already in 2010, 15 per cent of Spain's electricity demand was indeed met by its installed wind capacity, the UK is in the process of putting into operation the World´s largest offshore wind farm (the London array, whose foundations will be started in March will boast 1 GW of capacity), and Italy saw more than 5.5 GWh of energy produced from its combined small and large wind turbines.

The fact is that today, with preoccupations of both Climate Change and security of supply, larger wind turbines and wind farms are becoming part of everyday life. The problems associated with this new clean method for electricity production are being overcome rapidly year by year. However, currently big wind´s success is not being mirrored in its smaller sister industry. The installation of small-wind turbines is far from common-place, in fact it is more or less limited to rural off-grid applications, where photovoltaic installations still take preference. Although the potential for electricity generation from small-wind turbines does not reach the same impressive levels of that for big wind, the benefits that it can provide in terms of locally produced renewable energy, distributed energy generation, security of energy supply, very easy installation and lower environmental impact, mean that it must be considered as a vital contributor to our common energy future. Interestingly, the partner countries involved in the WICO project have a significant number of nationally based small-wind turbine manufacturers. Yet the internal market in these countries does not match the development of the industry and in particular Spain and the UK, export over 50% of their production. With such a strong technological base and good wind resources, particularly in coastal areas, the development of small-wind market only requires a few policy initiatives to see a boost within these countries themselves and this is what the industry is hoping for.

Despite the aforementioned positives, there exist a considerable number of barriers that need to be overcome if we are to see small-wind turbines enjoy the same success as large wind turbines. These barriers are explained and addressed in the WICO policy guidelines under three parallel lines of action: Policies, Market and Technology.

Wind Energy Resource and Potential

Wind resource and potential in each of the three countries involved in the WICO project and between differing European countries will be highly variable. Most countries have developed some form of wind map, mainly based on mathematics models, that demonstrate the wind velocities and thus the potential for wind energy in general in that country. The most pertinent maps for small-wind turbine purposes are those at 10 and 25 m. This is because most small-wind turbines will not be installed at a hub height greater than 30 metres. It must be pointed out that these maps can give you an idea of the potential within your area or region, but it is only an indication. Therefore, before installing a small-wind turbine the customer will have to speak with an expert in wind resources who will be able to evaluate the wind resource on the site more precisely. This study will not be as accurate as those necessary for big wind turbines, but will be adequate and is necessary in order to estimate annual energy output for different small-wind turbine models.

The three partner countries, Spain, Italy and UK, all have specific targets as part of their National Renewable Energy Action Plans and national strategies in wind energy.

Already having seen an impressive growth in its onshore wind farms, Spain intends to continue the trend with targets of 35GW onshore, 3GW offshore and 370MW of miniwind (small-wind) by 2020. This would mean a total of 38GW of installed wind capacity producing around 78TWh per year. The increase planned in small-wind will mean a step change from installing 5MW per year capacity in 2011 to 50MW/year between 2015-2020.

The UK does not have specific targets for small-wind energy , but estimates the contribution of wind energy to be 15GW of onshore and 13GW of offshore installed capacity by 2020, producing 34TWh and 44TWh per year respectively. The UK targets are for the combined Renewable sources to supply 30% of electricity supply by 2020, and 2% from small renewable energy sources like small-wind turbines.

Italy has targets to produce at least 17% of its energy consumption from renewable energy sources according to EU Directive. In 2010 Italy wrote the Renewable Energy Source National Planning document (Piano di azione nazionale per le energie rinnovabili (direttiva 2009/28/CE) where it is stated that in 2020 approximately 24 TWh will have to be produced from Wind Energy, translating into 12 GW of installed turbine capacity.

Applications of Small Wind Turbines

It may help to define what we mean by small-wind. The only international definition of a small-wind turbine is the one given by the IEC 61400 where wind turbines are divided depending upon their swept area. However, the definition varies very much from country to country, from administrative body to administrative body, and sometimes from planning authority to planning authority. For having said that, the general range for turbine power does not vary very much as it is mainly common sense. Therefore generalising according to all the various definitions that there are, we can state the following:

- Micro wind: of less than 1.5 kW of nominal power.
- Small/mini wind: 1.5 kW to 100 kW.
- Medium wind: 100 kW to 600 kW.
- Large wind: greater than 600 kW.

So in this document, although it is not set in stone, we are dealing with the policy decisions that will affect wind turbines with up to 100 kW nominal power.

Barring new innovative applications (such as production of hydrogen), the type of applications for which small-wind turbines will be applied are either off-grid installations most likely to be combined with photovoltaic cells, or to be injected into the low voltage grid for sale to the electricity distribution companies by net metering or the like. The former requires less administrative intervention than the latter in most cases, but has more technology issues although these are far from insurmountable. Off-grid applications are usually driven by necessity and most frequently found in rural isolated areas, whereas systems connected to the grid are often in more populated areas affecting planning, administration and turbine performance.

Advantages of Small Wind Turbine Installations

The installation process requires at least the following three steps:

1. Planning procedure (whose complexity depends on the environmental issues of the installation site).
2. Foundation design (size of the foundation depends on the soil characteristics),
3. Electrical/cabling design (its complexity depends on the type of installation (grid connected or stand-alone system) and on the grid availability).

Although small-wind installation process may be complex, particularly for grid-connected systems, it is more than compensated by the advantages it can offer. To name but a few:

- Provides power to off-grid locations
- Saves greenhouse gas emissions and other pollutants
- Enhances the reliability and power quality of the grid
- Reduces peak power demand
- Increases national electricity generation
- Diversifies the country´s energy supply portfolio
- Makes the electricity supply market more competitive by promoting consumer choice.

SMALL WIND APPLICATIONS- ISSUES & INITIATIVES

POLICIES

Regulatory Framework

European Legislation

The European Council, on 12 December 2008, and the European Parliament, on 17 December 2008, approved the Climate Package proposals of the European Commission. Also called the ‘‘20-20-20 plan’’, it aims to ensure the strict implementation of the commitment to reduce greenhouse emissions by 20% by 2020, to be achieved by:

- 20% reduction in greenhouse gas emissions.
- 20% improvement in energy efficiency.
- 20% share for renewables in the EU energy mix.

The Climate Package legislative package includes:

- A Directive improving and extending the greenhouse gas emission allowance trading system of the Community.
- A decision on the effort of Member States to reduce their greenhouse gas emissions
- A Directive on the promotion of the use of energy from renewable sources.
- A Directive on the geological storage of carbon dioxide.
- Regulation setting emission performance standards for new passenger cars.
- A Directive on quality specification of petrol, diesel and gas-oil.

The resulting legislation most pertinent to small-wind, as part of the package which provides a legislative framework for Community targets for greenhouse gas emission savings, is the resulting Renewable Energy Directive: *Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.* This Directive establishes a common framework for the production and promotion of energy from renewable sources. It encourages energy efficiency, energy consumption from renewable sources, the improvement of energy supply and the economic stimulation of a dynamic sector in which Europe is setting an example.

Article 4 of the Renewable Energy Directive (2009/28/EC) required Member States to submit national renewable energy action plans. These plans are intended to be roadmaps of how each Member State expects to reach its 2020 targets for the share of renewable energy in their energy mix. Individual member states are free to decide upon how they will actually go about this. Individual Member States have had to submit National Action Plans by 2010. Henceforth Member States will also be required to report their progress towards the interim and 2020 target every two years, from 2010.

Each Member State has been assigned a national target based upon its share of renewable energy production in 2005 and its per capita GDP. The Directive also obliges Government to ensure “Access to and Operation of the Grids”, ensuring that operators guarantee the transport and distribution of electricity from renewable sources and provide priority access for this type of energy.

Therefore, your national Renewable Energy Action Plan, is the main driver for promotion of small-wind in your country, and the scope for its development will most likely depend on the importance paid to it within the document text.

The action plans for the 27 member states can be found at:

http://ec.europa.eu/energy/renewables/transparency_platform/action_plan_en.htm

National and Regional Legislation

It is clearly beyond the scope of this document to analyse all legislation across the EU 27. The WICO project in WP 2 analysis framework has analysed the legislation in the UK, Spain, Italy, so please refer to this document if this is the particular country that you are interested in.

Most national and regional legislation will be directly related to the European Directives as these are the main drivers for renewable energy laws in the European Union. To what degree your regional or local authority is committed to the uptake of small-wind turbines may depend on many factors:

How the national renewable energy action plan has been drawn up; the political inclinations of the regional government and their corresponding commitment to renewable energy; the interest and openness at the local government level.

The legislation that governs the electricity grid, a key factor for the viability of connecting a small-wind turbine to the grid, will almost invariably be controlled by national law. Similarly legislation regarding the liberalisation of the energy market and the ease at which an individual can sell his energy to the distribution company will be nationally controlled.

On the other hand, when it comes to planning permission for the installation of a small-wind turbines, although the general framework may be controlled at national level, the responsibility for granting planning permission and the ease and speed at which it is processed normally lies with the local authority in cooperation with their regional authority.

Issues Faced

The WICO project has highlighted common themes throughout the partner countries most likely apply to all European nations and identified issues to be addressed if we are to achieve the objective of a wider uptake of small-wind turbines.

In many instances the planning process is excessively complicated and lengthy. In Spain the main issue as things stand is that there is no differentiation in the legislation between small-wind turbine installations and big wind turbine installations. What this means is that the same process needs to be followed legally to obtain permission for a 1 kW turbine as for a wind park of 20 MW. In Italy, there is a differentiation between the two (big and small-wind turbines) for planning purposes, if the installation site has no environmental restrictions, there is low tension grid availability and the nominal output power of the power plant is lower than 60kW then the turbine will be installed no more than 90 days. On the other hand if one of the requirements exceeds the limits then the installation process might take more than 1 year. In the UK the planning procedures are usually quite quick and various small-wind specific legislations exist, however the requirements to qualify for feed-in tariffs some consider excessively strict. Therefore, each country will have its own pitfalls either insufficient legislation, excessive legislation, or simply that the legislation is not being correctly and intelligently implemented. The following section draws on the conclusions from the WICO project partners on how best to ensure an effective legal framework to facilitate the uptake of small-wind turbine installations.

Policy Initiatives

P1. Legislation that stipulates the difference between small-wind and big wind

Where this distinction between small-wind and large wind is not made we run into serious difficulties. Large wind farms are an excellent form of clean energy aimed at providing energy in competition or in addition to fossil fuels power plant. Large wind farms have visual and environmental impacts that have to be investigated and evaluated before authorising their installation. Small-wind turbines on the other hand provide energy to small dwellings. Their visual and environmental impact is therefore very limited it makes no sense for small-wind turbines to have to undergo the same rigorous planning process as for big wind turbines. If this distinction is made at the national level it will almost certainly be fed down to the regional and local levels.

P2. Introduce a reliable and sustainable system of Feed-in tariffs to promote small-sacle wind turbines connected to the grid

Feed-in-tariffs are proving to be the most effective way to subsidise renewable energy particularly at the smaller scale. On April 1 2010 the UK introduced a new system of Feed-in-tariffs which has already seen an upsurge in small-wind installations. Italy too has seen considerable success with its with its 30 €c per kilowatt hour Feed-in tariffs. They are an effective way of reducing the payback time for these types of installations. This said they must be done in sustainable fashion. A classic example of the pitfalls to avoid has been given by the infamous photovoltaic Feed-in tariffs in Spain, which led to a boom-bust scenario (see Box 1).

THE RISE AND FALL

The solar industry in Spain has seen a huge growth in recent years, to such an extent that in 2008, Spain installed 45% of all photovoltaics worldwide. But a change in law limiting the Feed-in tariff has cause a precipitous drop in the rate of new installations, from an extraordinary 2500 MW in 2008 to an additional 375 MW in 2009.

The essential problem for the Spanish model was that the Spanish tariff of 0.44€, introduced back in 2007, led to a complete inundation of solar installations across Spain. The government was forced to make changes to the tariff system in 2008 reducing the tariff incentives 0.32-0.34€ and with investors already tied into long term deals and with large quantities of PV equipment already ordered, the results were extremely damaging.

To add salt to the wound, in reaction to serious economic and political pressure, a new Royal Decree 14/2010, will work by retroactively limiting the number of production hours that are eligible to receive the feed-in tariff. This will translate into a 30 percent cut in subsidies for some 90 percent of all PV plants for the next three years.

Box 1, PV boom-bust

P3. Accompany Feed-in-tariffs with time limits for competent authorities and obligations for connection

It is not particularly in the interests of the electricity distribution companies that individuals produce their own energy, therefore buying less from the distribution company and furthermore selling the excess to the grid. Legislation must therefore account for this as the European Renewable Energy Directive requires priority of dispatch for the energy produced from renewable energy sources. If this is not done procedures could be stalled for weeks, even years, invalidating any investment plan that the individual may have.

P4. Accompany all Feed-in tariffs and other monetary incentives with restrictions on the size of the installation

As mentioned, there is significant difference between big wind and small-wind installations, most notably in their visual impact. What a financial incentive must not do is allow the construction of small-wind parks thereby altering the low impact characteristics associated with a small-wind installations. In short it will be counterproductive and meet with resistance. This is precisely what has been done in Portugal where law DL-363/2007 gives the very generous Feed-in tariff of 0,43€c/kWh but only to installations of less than 3,68kW.

P5. Allow the possibility of net metering

Again this will most probably be the responsibility of the national government and the electricity distribution legislation. If Feed-in tariffs are not possible then another option is called net metering. This is where the individual can sell all the excess energy to the grid but at the going electricity price. All it needs is a meter that runs both forwards and backwards and at the end of each month or quarter the individual will pay the difference between their consumption and their production. However the same difficulties arise as with Feed-in-tariffs whereby the distribution company must be obliged to allow feeding in of energy into the grid, and to facilitate the start-up of the operation within a reasonable time frame.

Most of the above initiatives can only be implemented in cooperation with the national bodies as it refers to national laws and national norms. Although the scope within which the industry can develop small-wind installations will depend very heavily on how the European directives are being adequately integrated.

P6. Reduce tax burden on individual who wishes to install

A small-wind turbine installation even if it is Grid-connected with a Feed-in-tariffs is unlikely to generate much income for an investor or individual. Most installations will be out of necessity because the site is off-grid or for ecologically motivated reasons, possibly with some level of profits. Imposing excessive tax burdens on the electricity producer at this scale works against business and compromises the viability of the installation. To have to register as self employed and pay hundreds of euros per month as if it were a business does not make sense. Furthermore, to truly promote this clean form of energy, ideally all income from it should be tax free. Although some of the tax issues will have to be resolved at national level there may well be local fees and taxes that can be reduced accordingly to encourage more uptake.

A TAXING AFFAIR

In some countries it is necessary to register as self-employed to be able to sell energy for your own small installations, which with this being prohibitively expensive in many of these countries (as much as 300€ per month regardless of income), will render unviable any grid-connected small-scale system. Some countries have introduced tax-breaks to overcome such complications:

In the UK, VAT (Value Added Tax) is reduced to 5% for small wind turbines. Additionally, sale to the grid through the Feed-in tariff scheme is also tax free (does not have to be declared) for all residential customers, which gives the full benefit of the energy sale.

In Italy, although Feed-in tariff income has to be declared in tax returns, there is a reduced VAT rate from 20% to 10% for components and power systems that produce energy from PV panels and/or wind turbines.

Box 2, Example of tax-breaks for small-wind

Administration

Administrative norms

One of the main issues identified by the WICO project are administrative deficiencies in practically all countries which create an artificial barrier to smooth processing of small-wind installations. This is not necessarily surprising as we are dealing with a relatively new energy model that requires reforms to our administrative procedures. The two main policy lines that may affect a small-wind installation are: Planning Law and Environmental Law.

Planning Law

Planning law will be different between countries, regions and locally. However more or less the same issues will always have to be addressed. For example: the permitted height of the turbine; the length of time to process an application; the limit for turbine capacity; certificates from the installer; certificates for the wind turbine; noise nuisance; flicker issues; social impact; current designated land use category; building regulations.

Dealing with planning permission for small-wind turbines is a particularly sticky subject especially when there is no specific reference in local planning law to small-wind. Some countries are introducing specific guidance and legislation to take this technology into account, however in most cases it is the local municipal officers that must resolve the issues. This brings up a significant issue identified by the WICO project: there is a notable lack of training and information on small-wind for local and regional municipal officers. As well as providing policy guidelines, this document also aims to give practical assistance to these municipal officers that are having to deal with the day-to-day of such applications.

Environmental Law

Again Environmental Law will be different depending on your locality. However the environmental laws are usually national, the majority of which will have been drawn up following European Directives. The environmental impacts of a small-wind turbine installation are minimal yet such installations often get confused with larger wind farms due to a lack of knowledge and misperception. Where there are no specific inclusions or articles regarding small-wind turbines in environmental regulations, its categorisation alongside its larger sister can result in failed applications or very long delays which may render the investment unviable. For example, in Andalusia, the same environmental law (GICA) applies to both small and large turbines when they are to be connected to the grid. As a result, there are no cases of legally installed small-wind turbines connected to the grid in Andalusia. Requiring an environmental impact assessment for a small installation is clearly unnecessary but without laws that differentiate between the two types, it is inevitable that environmental officers and planning officers will find decision-making extremely difficult.

It is to be expected as with all new technologies that laws and regulations will take time to be optimised for their inclusion. Therefore the local municipal administrators must know what their respective laws are but at the same time have an understanding of the real issues and real environmental impacts of small-wind installations.

Procedures

Procedures come under pretty much the same headings in all European countries: planning permission, environmental authorisation and where applicable operating permits for grid connection.

Planning permission

A small-wind turbine will need to be mounted either on a tall tower (12m or more) or on a metal structure on a rooftop. This structure and the turbine itself will almost invariably require an application to the local authority for planning permission. The length of time to acquire such permits varies enormously between countries making it one of the key issues to address. In some countries permission must be granted within 8 weeks, and in others delays can last up to two years!

Administrative Authorisation

This is very closely linked to the granting of planning permission. I.e. To what extent the new construction is in line with the pertinent environmental laws and to take into account any exceptional circumstances (for example, if the installation is in a very sensitive area for environmental, military or other reasons). Depending on the country, this will be necessary before the granting of planning permission or be included as a part of the planning permission process.

Permits for Grid Connection

Grid connection too varies very much from country to country. In Italy once you apply, the electricity company has a maximum of 60 days to provide you with a technical solution from which date they have 90 days to complete the connection. In the UK the electricity company is obliged to connect you up to 16 amps per phase. In Spain there is discussion for similar laws to be applied but as of yet nothing has been approved. In all cases some form of permission will be needed, ideally available within a short time frame. Insufficient regulation here could compromise safety and quality of the electricity network in the locality or on the other hand, excessive regulation can allow electricity companies to stall the granting of permissions and hence the whole installation procedure.

Policy Initiatives

A1. Develop local by-laws specifically geared for small-wind

As well as providing a general framework in which to develop small-wind installations, the by-laws should clearly differentiate between small-wind installations and large wind farms. It is important at the local and regional level as it is at national level to recognise the clear differences between what is a very low impact small-scale wind installation and a high impact large scale wind farm. Local or regional guidelines and by-laws must contain a distinction between the two or more scales of wind turbines. Las Palmas in the Canary Islands is the first spanish municipality to develop a special by-law for small-wind, set to be a trail-blazer for the rest of the iberian peninsular. For an example of a local by-law see Annex C.

A2. Streamline bureaucracy specially geared for small-wind

Being a low impact small-scale operation bureaucratic demands over and above what is reasonable can only lead to stagnation of the industry. In many European countries the process for obtaining planning permission, authorisation. and permits is too complicated and leads to the installation taking place either illegally or not taking place at all. Such simplification is being considered in the UK by making small-wind turbine installations a “permitted development” under the town and country planning amendment order 2008. What this would mean is that as long as the installation meets with certain requirements it will not have to go through the planning process and will act as a real stimulus for interested individuals. An example of a small-wind turbine “permitted development” is shown in the Figure 1 below.

A3. Fast-track administrative procedures

It is not just the simplification of procedures but also quicker processing time. In some countries there are strict obligations on the local authority to communicate its planning adjudication within a certain number of weeks, such as in the UK. In Italy too there are relatively strict time limits but as there are no penalties for surpassing the time limit often they are not always adhered to. In other countries there are no time limits which means the process can drag out for many months if not years. Therefore a vital role that local and regional administrations have to play is that of Fast-tracking the administrative procedures for small-wind turbine installations.

A4. Training of key administrative personnel

In many cases across Europe the local municipal officers and sometimes regional responsible officers are not au fait with the characteristics of small-wind turbine installations. This knowledge gap creates problems for the administration, problems for the developer, and problems for the market. The local and regional government should provide training and clear guidance for its staff to ensure that correct decisions are made in short time frames whilst neither compromising safety nor performance of the renewable energy installation.

The RuralRES project, an Intelligent Energy Europe project involving partners from 7 EU countries has provided materials precisely to provide training for the various stakeholders relevant to small wind installations as part of its outputs (see Box 6 later in the document for more details). Any training programme could therefore draw on the experience from this project, as well as that of WICO.

A5. Minimize administrative fee burden on installer or owner

Imposing high administrative charges, fees or taxes, should not be permitted. The installer is contributing to environmental protection, energy distribution and security of supply and should not be penalised for doing so. So taxes and fees must be reduced to a minimum for this type of installation within local and regional legislation.

A6. Provide consistency at all levels of policy and legislation

Many countries are characterised by inconsistencies between national/regional policy and between competent bodies in definitions and thresholds for what is considered to be a small-wind turbine. For example, in Italy, 1 MW is the threshold for an environmental impact assessment, 60 kW for the DIA procedure (this means that you should get the installation approval within 30 days from the municipality), and 20 kW the limit at which you will be considered an industrial producer of energy for tax purposes. More consistency between administrative levels and other competent bodies, such as the electricity distribution companies, will lead to a much clearer picture for the installer and individual. This will require coordination and cooperation when drawing up specific policies in this area.

TECHNOLOGY LIMITS TO PERMITTED DEVELOPMENT RIGHTS	
Wind free standing	◆ Maximum 15m hub height for horizontal mounted axial flow wind turbines (maximum of 15m height in total for other turbines). ◆ Maximum blade diameter of 6m for horizontal mounted axial flow wind turbines (maximum swept area of 28m2 for other turbines). ◆ Blade must be a minimum of 5m from the ground. ◆ Device and installer must be certified by a UKAS accredited microgeneration certification scheme. ◆ Colour scheme to be reasonably in keeping with surroundings. ◆ Installer must inform the statutory nature conservation body in writing of the location of the turbine before it is erected. ◆ Not within 200m of any other free standing wind turbine. ◆ Remove if not in use for six months. ◆ No permitted development in national parks, AONBs, conservation areas, world heritage sites or within the cartilage of a listed building.
Wind Building mounted	◆ Maximum turbine height 3m higher than ridge line (or highest part of roof for flat roofs). ◆ Maximum blade diameter of 2.5m for horizontal axis axial flow wind turbines (maximum swept area of 5m2 for other turbines). ◆ Maximum of 1 turbine on buildings of 15m or less in height, maximum of 4 turbines on buildings of more than 15m in height. ◆ Colour scheme to be reasonably in keeping with surroundings. ◆ Remove if not in use for six months. ◆ No permitted development within conservation areas or world heritage sites. ◆ Device and installer must be certified by a UKAS accredited microgeneration certification scheme.

Figure 1, Example of Permitted Development, exempt from planning process

MARKET

Financial Issues

Costs

The costs for small-wind turbine installations can be generally split into the following:

- Initial Feasibility study (usually minimal)
- The Turbine itself
- Tower Structure
- Inverter
- Batteries (if off-grid)
- Connection to grid (if grid-connected)
- Other electrical equipment
- Licences and Permissions
- Business taxes (if not exempt)

Two examples of typical costs split, one for off-grid and one for grid-connection, taken from different sources are shown in Figure 2 and Figure 3 below:

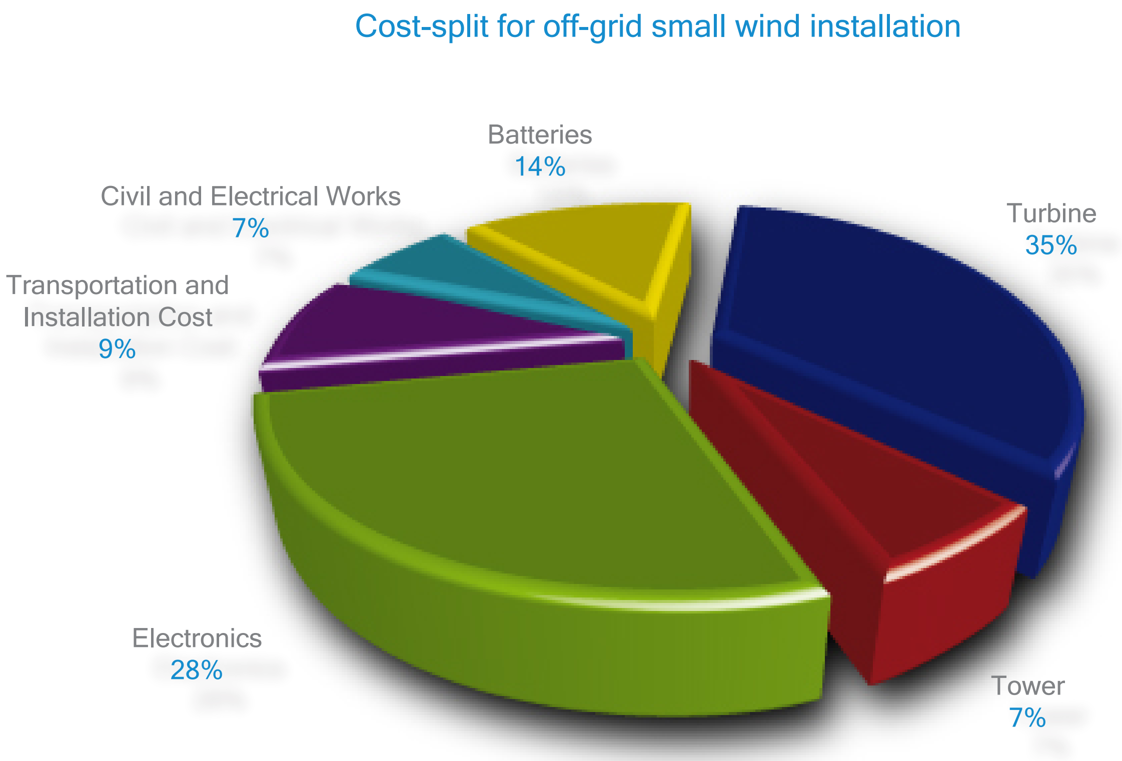


Figure 2, Cost-split for off-grid small wind installation

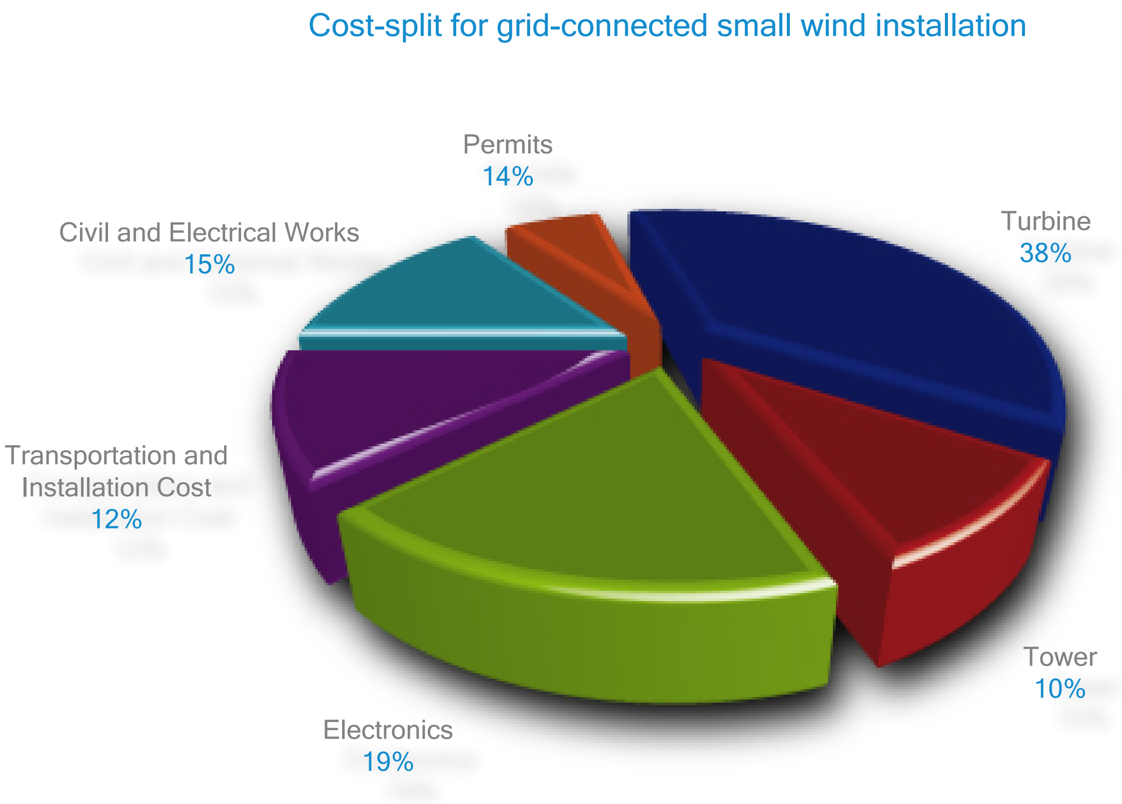


Figure 3, Cost-split for grid-connected small wind system

The split can obviously vary significantly depending on type and size of turbine, tower height etc. but the examples above give a general idea of the kind of split we are looking at.

It is very difficult to generalize in terms of absolute costs for small-wind installations. Obviously a 50kW turbine will cost significantly more than a 2 kW turbine. It is also misleading to generalize on costs per kW of nominal power, as this can vary from between 1€ per W for the cheapest import to 5€ per W for specialised turbines. We must remember that wind turbines produce energy and therefore their reference value should really be per kWh: therefore the correct way to compare the costs of small-wind turbines is their total cost (turn-key installation) divided by their production during their life (generally 10-20 years).

The costs of the turbines must be therefore analysed case by case to evaluate its value for money. For example, a 10kW system costing 50.000 € installed in a position with an average wind velocity of 8 m/s that produces 20MWh per year, is very different from a 1,5kW costing only 3500 €, but with average wind velocity of 4m/s that produces a lowly 650 kWh per year. In the first case, presuming a period of 10 years operation (ignoring maintenance costs), gives a cost of 25 €c/kWh, whereas the second case gives one of 54 €c/kWh.

However, in both of the cases above, and invariably in small-wind and photovoltaic installations, it is clear that the price per kWh of electricity is considerably higher than the cost of electricity form the grid today. As an example, the WICO partners average electricity prices for a normal household including taxes, for Italy, Spain and UK they are roughly 19, 17 & 13 €c/kWh respectively. Therefore in order to be viable, some form of financial incentive is usually necessary to compensate for its comparative expense when compared to conventional sources of energy[1].

[1] The Met Office study for the Carbon Trust suggests that some potential rural installations have costs of energy below 12p/kWh, suggesting their electricity is competitive with grid electricity; but this must be treated with caution, as it is a surprisingly low figure.

This can be justified for a number of reasons:

1. Wind power is a sustainable and renewable form of energy. The externalities of conventional forms of energy are not included in their natural market price, i.e. the direct environmental costs of burning fossil fuels, the Health costs resulting from pollution, the damage to future generations' well-being due to Climate Change. Therefore subsidies can be justified to correct for the what is considered in Economics, to be a market failure.

2. The European Union, is as whole 53,8% Energy dependent. That is to say it has to import over half its energy needs from the rest of the World, and the tendency is increasing. Some countries like Spain and Italy are over 80% Energy dependent. Therefore for reasons of Energy Security, subsidising home-produced energy, has many political and strategic advantages- it means less dependency on the reliability and costs of imported coal, gas, uranium etc.

3. It can assist in the acceleration to maturity of the small-wind turbine industry. So far there are no mass produced small-wind turbines in Europe, in fact the only possible producer that could be considered to have mass production is that of SouthWest windpower in the United States. This means that considerable economies of scale are still yet to be harnessed and give significant potential for cost reduction and increased application of wind power. It gives a boost to the industry which could lead to exponential future benefits.

One of the biggest financial barriers to the uptake of small renewable installations is the high up-front capital investment costs. This is particularly poignant when Net Present Value and Internal Rate of Return financial studies are performed with significant discount rates. The up-front cost has a higher weighting than the future benefits. Therefore financial assistance is justified to facilitate deployment of renewable energy technologies, and various innovative financial mechanisms can be developed to reduce the cost differential between conventional and renewable technologies, and address investor concern about high initial capital costs.

Policy Initiatives

There are various methods for providing financial incentives for small-scale renewable energies the best known of which are Grants and Feed-in-Tariffs.

F1. Provide grants for small-wind turbine installations

Grants are direct subsidies for the installation of system. Their advantage over Feed-in tariffs, is that they can provide support to off-grid installations and they can be administered at a more local level. Feed-in-tariffs will normally need to be granted at national level. They help overcome the financial barrier of high up-front initial investment costs, and can give a boost to the financial viability to the project as a whole, as well as providing a "carrot" to any keen individual or investor. The idea is to provide an initial boost to the uptake of systems, which will subsequently lead to economies of scale and a natural descent in system prices. However they must be designed so as to ensure that the resultant cost reductions are passed on to the consumer. To be avoided are schemes where grants are given to the installer, yet they sell systems at a similar final price to the consumer as before, whilst boosting their profits with the grant. This will not lead to higher uptake, nor to the desired medium term cost reduction.

F2. (as P2) Introduce a reliable and sustainable system of Feed-in tariffs to promote small-scale wind turbines connected to the grid

Feed-in-Tariffs have already been introduced as a policy incentive in P2, as it must be passed at the national level through specific legislation. They have proved highly effective means of boosting renewable energy. However, their main disadvantage is that the subsidy is directly passed on to consumers through a higher electricity price. It is the electricity distributors that have to pay the Feed-in tariffs to the renewable producer and the extra costs are spread across the electricity prices through to the consumer, increasing by a few €c the cost of electricity. At a time of economic difficulty this can cause social discontent and a negative reaction against the support for renewables. Financial support to other energies, like nuclear or coal is “disguised” through general government budgets, and thus through general taxation. Although the taxpayer is having to finance the subsidies, as it is not a transparent tax, the public do not associate their tax rate with the support for conventional energy sources.

PUT INTO PERSPECTIVE

Financial incentives in the form of subsidies or Feed-in tariffs can meet with much criticism from many sectors and interested parties. Renewables can be accused of wasting public money in what would otherwise be an unprofitable business, or causing a rise in electricity unit prices that negatively affect the incomes of all citizens, in particular the poorest. At face value some of these criticisms can seem justified. However, the arguments more often than not turn out to be specious ones, particularly if the following is taking into account:

“Bloomberg’s own analysis puts worldwide incentives for renewable energy sources last year at $43 - 46 billion. International Energy Agency data for 2008 counted the fossil fuel industry’s tally at a whopping $557 billion.” (http://inhabitat.com/fossil-fuels-receive-12x-more-subsidies-than-renewables/obamasolar-ed01-2/)

Box 3, subsidies to renewable compared to fossil fuels

In the case where Feed-in tariffs are not viable, or purely as a simpler alternative for small-wind energy producers, a system of net-metering can be introduced. Net metering is a simplified method of metering both the energy consumed from the grid and the wind power produced by a small-wind turbine where electricity produced by the wind turbine in excess of the customer’s needs at any given time will be fed onto the electricity grid. Thus the excess wind generation either spins the customer’s electricity meter backwards or is read from a second meter and balanced against the customer’s outgoing meter. The electricity is effectively banked until the customer’s demand for electricity exceeds on-site generation, providing the customer with full retail value for all the electricity produced. Agreements will have to be made, or obligations will have to be put on the electricity distribution companies, which may require new national legislation. Net-metering can be a powerful, yet simple financial incentive that can render many installations viable that may otherwise not be so.

F3. Facilitate low interest loan schemes for individuals to finance small scale renewable installations

The public sector can act as a guarantor or facilitator for low interest loans to be provided for specific types of installations. Either by pooling risk, or the simple technical assistance that a local or regional authority can provide, they may convince the financial institutions to provide financing at lower credit rates. A fully detailed analysis of all the financing possibilities is beyond the scope of this document, but a highly recommended read for policy-makers on this topic is the document "All Money is not the Same" by Eurada, and can be found at: http://www.eurada.org/site/files/Access%20to%20finance/All%20money%20is%20not%20the%20same_E.pdf

F4. Promote innovative financing mechanisms, like Third Party Financing and Results Purchasing

Third Party Financing Third Party Finance (TPF) contracts is when a third party other than the buyer or seller of the renewable energy equipment, puts up the finance to pay for the installation, and then charges the user according to the contract that is drawn up. The most common application of this scheme is where utility companies or ESCO (Energy Services Company) buy the technology, pay for the installation and then pass the costs onto the end user by means of selling units of energy. Alternatively the mechanism could be a "fee-for-service", where the customer simply pays a monthly fee for the benefit of this.

The concept of Results Purchasing was invented to avoid the two principle problems associated with renewable energy: the high initial capital costs, and the lack of confidence in the delivered energy that can be expected from the technology. A system of Third Party Financing to overcome the first problem, with Guaranteed Results to overcome the second. It can take various forms: A flat rate tariff each month regardless of energy used; a per unit tariff where money is paid according to quantity of energy used; an energy service contract or "fee-for-service" where the user pays for the delivery of a certain amount of energy. Results purchasing removes all uncertainty that a client may have that a system will not perform well by guaranteeing that, over an agreed period, they will receive a given amount of energy from their installation. If the installation does not perform to the standard set out in the guarantee, the client is compensated financially for the failure.

The risk is, that if the system is not assessed accurately, the system performance model will not be correct. The cost of accurate metering or monitoring must be factored into the installation. There is also the added problem that ownership is never transferred to the user and hence the hardware installed is prone to vandalism, neglect and misuse.

FIT FOR PURPOSE

In April 2010, the UK government created a Feed-in Tariff (FiT) system which have displaced ROCs (Renewables Obligation Certificates) as the choice reward for various competing forms of microgeneration including small-wind. FiT offer a better return than ROC up to 1500kW (9.4 p/kWh). Above 1.5MW up to the ceiling of 5MW they are less favourable (4.5 p/kWh) whereas ROCs previously were worth up to 9p/kWh.

The aim of the new FiT system is quoted as follows:

"Tariff levels have been set to provide an expected rate of return, in real terms, of approximately 5-8% for well sited installations, taking into account the risks associated with deploying the different technologies and the likely effect those risks would have on investors' willingness to invest. As the tariffs are linked to inflation, in nominal terms this rate of return could then be considered to be approximately 7-10%."

FiT offer the best financial arrangement for small-wind turbines, and well sited installations should see a return of 8% on capital excluding land cost.

In Italy too, FiT have been the choice stimulation for the small-wind industry. Wind installations whose maximum output power is lower than 200 kW get a Feed-in tariff according to Ministry Decree dated 18th December 2008, (DM n. 244, art.3, comma 2, ed art. 17 commi 1 e 2 called "tariffa omnicomprensiva") that gives 0.30 € for each kWh.

Box 4, Feed-in tariff examples

TAKE FOR GRANTED

PROSOL has been promoted by the Andalusian Ministry for Innovation, Science and Business through the Andalusian Energy Agency (AAE) to promote, develop and implement quality-assured renewable energy installations, part-financed by ERDF funds.

The main aims of the PROSOL progamme are to: provide guarantees for citizens; give easy access to grants; develop specialized business sector; provide a quick and transparent procedure; promote installations.

The installation must be performed by accredited company (see Box 8) and the maximum grant available is up to 70% for the whole programme. Although in 2007 for mixed PV-wind systems it was up to 40%, this has dropped to around 20-30% depending on the system.

The PROSOL Project has been extremely successful, in 2008 grants were awarded to over 500kW of installed PV and 24kW of mixed PV-wind installations. Since its inception, PROSOL has overseen more than 8650 installations in Andalusia, representing an investment of 80 million euros, with 27 million euros of grants delivered, most of which has benefited individual citizens directly.

For more information please visit: http://www.agenciaandaluzadelaenergia.es/agenciadelaenergia/nav/com/contenido.jsp?pag=/contenidos/incentivos/incentivos_09

Box 5, Subsidy scheme example- PROSOL

Social Issues

Society´s Perception

Society's perception is a key aspect in the introduction of any new technology. It must be met with favour, in particular by local people, if its development and success are to be assured. Much of Society today has a relatively high environmental awareness, thanks to many years of campaigns and the media coverage that Climate Change receives. Very few people would consider themselves "against" Renewable Energy. However, despite this wind power is not without its critics and is often victim of a significant degree of negative perceptions. This is due to various reasons, for example: genuine issues; lack of knowledge; negative propaganda by vested interest; lack of compromise.

The most common argument you will hear against wind turbines are that they are noisy, cause accidents, destroy the landscape and kill rare species of birds. Although not totally founded on myths, these problems are usually highly exaggerated, and particularly in the case of small-wind turbines. As mentioned earlier in the document, there is a big divide between small-wind and big wind, unfortunately not always recognized in the national legislation. In the same way, the distinction in individuals' perception between the two types of wind energy is frequently not made.

Visual Impact

Small-wind turbines are installed on towers whose height is normally between 6 to 30 metres for wind resource and performance reasons and therefore their visibility varies for each site depending upon the surrounding environment. However, visibility is not the same as visual impact. People are used to seeing electricity and telephone pylons, water towers, mobile phone transmitters dotted all over the countryside and towns. The relative impact of small-wind turbine installations, will be minimal. However, as it is perception that we are dealing with, care must be taken, especially in visually sensitive areas, for example protected areas, ridges etc. Inappropriate siting of an installation could generate conflicts between residents, municipal officials and small-wind turbine owners. Furthermore these conflicts could create hostilities not only to the small-wind market, but to wind development in general, since the public tends to associate the technologies together despite their significant differences.

Flicker

Related to visual impact, flicker is the strobe effect caused by rotating devices with the risk that it can provoke epilepsy. As sunlight passes through moving blades, it can cause a flickering effect in 'line of sight' directions, and this possibility should be considered at the site selection stage also considering the density of the population in that area. It is normally possible to avoid this problem and reflections from the blades are unlikely, especially as the blade coatings used on modern turbines have been selected to minimise reflection.

Noise

This is a very delicate issue ruled by norm IEC 61400 that stipulates limits for noise emissions at different wind speeds that wind turbines must meet.

The majority of modern small-wind turbines have been designed to respect the IEC 61400 norm and therefore municipal officers must require a noise emission test in order to avoid any problem related to noise. During selection site stage, one should take into account that the noisiest area around a wind turbine is approximately 2-4 rotor diameters far from the wind turbine at 45° from wind incoming direction. Additionally, roof-mounted small-wind turbines might make noise due to resonance frequencies with the house which must be considered during selection site stage.

Threat to wildlife

Large wind turbines have had bad press regarding their impacts on birdlife, particularly migratory birds. Quoted from the RSPB website *"Poorly sited wind farms have caused some major bird casualties, particularly in Tarifa and Navarra in Spain, and the Altamont Pass in California. At these sites, planners failed to consider adequately the likely impact of putting hundreds, or even thousands, of turbines in areas that are important for birds of prey. Tragically, killing many hundreds of birds as a result. If wind farms are located away from major migration routes and important feeding, breeding and roosting areas of those bird species known or suspected to be at risk, there is a strong possibility that they will have minimal impact on wildlife."*

(http://www.rspb.org.uk/ourwork/policy/windfarms/index.aspx)

Thus although caution must be applied, the chances that an isolated small-wind turbine will cause bird kills, is unlikely.

If a wind turbine is correctly installed it should have minimal visual impact, not create any noise nuisance and no threat to wildlife.

Policy Iniatives

As mentioned above, most of the criticisms applied to small-wind turbines are fallacious. However the lack of clear information and accurate reporting can lead to serious misperceptions and become an important barrier to wider uptake of small-wind installations.

S1. Provide information and awareness campaigns for the general public

Good public relations are key to realising successful uptake of small-wind technologies. Information campaigns and awareness raising are a highly recommended method to achieve this, particularly as most of the social barriers to the uptake of small-wind systems are misperceptions. The public need to be not only reminded of the environmental benefits of this form of renewable energy, but also reassured that it will not be visually intrusive, that it will not create a noise nuisance and is a minimal threat to wildlife. Any local benefits should also be stressed, the benefits of locally produced electricity, with local installers and if possible with national wind turbine manufacturers. This way its contribution to the local economy and employment can be emphasised. It is always better for local citizens to have a “buy-in” to any new installation, albeit an abstract one. That way, any supposed inconvenience that may be caused by the turbine will be much more easily accepted. For example, the noise of aircraft to those living near an airport is not as disturbing to the airport staff who make a living from it, as to those who have no connection with it.

An example of one type of action would be to organize free workshop and press release where the future wind installations is publically presented to show the low impact that these turbines have, and dispel any myths that the public may have, as well as stressing its benefits.

S2. Provide information campaigns for politicians and other key decision-makers

The misperceptions mentioned not only apply to citizens, but are also mirrored also in politicians and other key decision-makers. Equally important as correctly informing the public is to provide training or materials for politicians and top local and regional government officials, which is, in effect, what this document aims to address. It must be hand-in-hand with citizen awareness campaigns. If only the politician is aware of the advantages, yet citizens are heavily biased against installations, the politician, as public representatives, and with a necessity for votes come the next elections, cannot go against the grain of public opinion. Hence they will not act in favour of installations. Vice versa, if citizens are aware and in favour, yet politicians have not been correctly informed, the politicians will lack the information and tools to take the correct decisions for Society as a whole. Therefore, concurrent information campaigns should be undertaken for both the public and politicians.

S3. Take preventive measures to avoid feeding misperception- provide clear guidelines

Isolated bad-news stories can do serious damage to the development of Renewable Energy. If there already exists a negative perception, such as “wind turbines kill birds”, and the planning authority and other bodies allow a turbine to be installed right next to a rare bird’s nest, then clearly we are creating a worst-case scenario and feeding the misperception. Clear guidelines must be drawn up for planners and all other relevant officers. For example:

- Judge visual impacts on a case-by-case basis taking note of sensitive areas, ridges, sites of historic value etc.
- That the mean value of the sound pressure level from small-wind energy systems shall not exceed what IEC 61400 states above background sound, except during short-term events such as severe storms.
- Presence of any rare birdlife in the vicinity must be taken into account and the turbine be placed at least 50m from the nest.

So Guidelines similar to those seen in Figure 1, page 23 are recommended, but with additional points to placate any social concerns, and avoid worst-case scenarios.

S4. Consult with citizens within the local vicinity

A highly recommended procedure that installers, investors or owners should follow, is to always consult and inform the neighbouring property of the intention to mount a small-wind turbine. It is most likely that if clearly explained, and the turbine is far enough from their property, that this will be simply a polite gesture that will ensure no unpleasant surprises at the time of processing planning permission. In the case of difficulty, the installing party can resolve any issues before installation and planning, rather than dealing with sticky and time-consuming situations further down the line.

S5. Avoid large miniwind parks

As mentioned previously in Policy Initiative P4 with regard to Feed-in tariffs, it is a particular concern that favourable financial incentives could lead to the installation of large scale miniwind farms by speculators. That is to say, a large area of land with many small wind turbines. Of course, the typical low-scale impact characteristics of small-wind installations disappear dramatically with such an application of the technology. It can be paralleled to the “huertos solares” which transform previously minimalistic photovoltaic installations into financial projects that take up vast tracts of agricultural land with significant visual impact. Ideas for avoiding such a development which would most likely be counter-productive have already been presented. For example, the new draft Royal Decree for microgeneration in Spain would limit the Feed-in tariffs to be paid for electricity production of only up to 150% production relative to the electricity supply contract for the site. In such a way, the owner, investor, installer will be given a boost to ensure viability of their financial model, but without being open to the development of many turbines feeding hundreds of kW into the grid. A similar limitation is actually in force in Portugal which limits Feed-in tariffs to installations smaller than 3,68kW.

S6. Install Educational small-wind systems

This is an initiative ideal to be carried out at the local municipality level. Small-scale wind installations can act as an educational tool and as a driver within the local area for more uptake of these types of installations. Placed in a prominent location for educational purposes, it can be used to demonstrate the technologies to school children, students and visitors. Innovative designs such as vertical axis wind turbines could be installed as financial viability would not be the prime objective and combined with monitoring could provide valuable trials for newer, less tested technologies.

Furthermore, the installation of a group of such turbines, for example, on municipal buildings, could be part of the Sustainable Energy Action Plan, under the Covenant of Mayors initiative for municipalities, and even contribute to its 20-20-20 goals.

TECHNOLOGY

Market Situation

Prices

The costs of small-wind energy conversion systems have been dealt with in the Costs, pages 24 & 25. In general the costs of small-wind systems are relatively elevated. When compared to Photovoltaic prices, they can appear similar, yet caution must be applied. Prices per Watt of PV are around 3 €/Wp, and you can get reasonable quality wind turbines for around the same price per W of installed nominal power. However, in most cases you must take into account the additional costs of the tower of the wind turbine, and its Capacity Factor should be compared to the alternatives in your area. For example, in Andalusia, a good quality PV panel will give you a Capacity Factor of around 20%, whereas a small-wind turbine is unlikely to give you more than 15%. Vice versa, in the UK, the tables could well be turned more in favour of the small-wind turbine in terms of production per € invested.

Although price per Wp or W nominal are important to look at, expected annual energy production is a much better indicator for comparing unitary prices between different technologies (see section below on “Predicting Real Production”). However, this may be somewhat immaterial, as often the complementary nature of wind/PV hybrid systems in off-grid applications means that both technologies are often chosen, despite preponderance of one compared to the other in value-for-money terms.

Efficiency

There are many factors affecting the efficiency of a wind turbine. Efficiency can be described as the ratio of the useful energy output to the energy input. The efficiency-types relevant to wind energy are aerodynamic, thermal, mechanical and electrical efficiencies. These efficiencies account for energy losses. To compare this with conventional electricity production: the average efficiency of electricity generation infrastructure is usually about 40% because in most thermal plants about two thirds of the input energy is lost as heat. The mechanical conversion efficiency of commercial wind turbines is therefore comparatively high, in the range of 90%. However it only is able to use a certain percentage of the wind energy available, and can only operate when sufficient wind is blowing.

The two main efficiencies usually stated for small-wind turbine are explained below:

Power Coefficient (Cp)

The power given by a turbine is expressed in the following Wind Turbine Power Equation:

$P = 0{,}5.\rho.Cp.A.v^3$

where:
P = power in Watts
ρ = air density (about 1,225 kg/m^3 at sea level)
A = rotor swept area (m^2)
Cp = Power Coefficient (0,59 {Betz limit} is the maximum theoretically possible, 0,35 for a good design)
v = wind speed in m/s

The Cp is the overall efficiency of power conversion ratio, and varies with both rotor and wind turbine components and design. Theoretically it cannot exceed the aerodynamic Betz limit equal to 0,593: this value is the maximum ratio of energy that any turbine can extract from air flow. It will depend on the rotor design, but also on the conditions under which it has been placed. For example some wind turbines may have high performance at a wind speed of 8m/s (excellent Cp approaching 0,35) and unimpressive Cp value at wind speed of less than 6m/s.

Beware of Power Coefficients higher than the above mentioned: manufacturers or installers sometimes claim results that break the laws of physics! In the case of small-wind energy systems, any Cp that appears above 0,35 must be treated as a misrepresentation or worse. For example, if a manufacturer claims that their turbine that has a swept area (A) of 7m^2 will give you 500W of power at a wind speed of 5m/s, then this presumes a Cp of 0,93 (Cp=500/(0,5*1,225*7*125)). Then they are either mistaken or being deliberately misleading.

Capacity Factor (CF)

The Capacity Factor, is a commonly used coefficient for representing the annual energy production of a wind turbine installed in a certain site. It is related to the nominal power of the wind turbine. The Capacity Factor is a theoretical value expressed as a percentage. See the following example: a 2 kW nominal power turbine, will have a theoretical annual production of 2kW*8760h= 17520kWh/year. Obviously this value is unrealistic because the turbine is only functioning in certain wind conditions, and often well below its nominal power. Thus, once the theoretical annual production is calculated, an estimate, or measurement is then performed on the real production that the wind turbine will give, at a specific site.

The real production (measured or evaluated) is then divided by the theoretical annual energy production and a percentage is the result, which is called the Capacity Factor. Therefore if the 2kW turbine actually gives us 3504 kWh/year, the Capacity Factor would be 20% (3504/17520). Large wind farms, due to their optimal locations, and ability to operate at their nominal power rating give Capacity Factors around 30%, whereas small-wind turbines, if incorrectly sited, have Capacity Factors lower than 5%. If correctly sited, a small-wind turbine should give a Capacity Factor of between 10-20%.

Carbon Efficiency

According to the Carbon Trust (UK), small-wind turbines will pay back the energy used, and offset the CO_2 emitted in their manufacture, within the first two years of installation. (Based on the common sense approach of an installation correctly sited with reasonable wind conditions.) The rest of its useful life will be pure CO_2 savings.

Large modern wind turbines payback is even better. According to the BWEA (now RenewableUK), they will pay back the energy used, and offset the CO_2 emitted in their manufacture , within 2-10 months. As the turbines have a life-expectancy of 20-25 years, the carbon savings are excellent.

Safety and Reliability

Due to the lack of accreditation to the International Standards, the industry of small-wind turbines is plagued by certain issues, as highlighted by R&D experts of the International Energy Agency 49th Topical Expert Meeting:

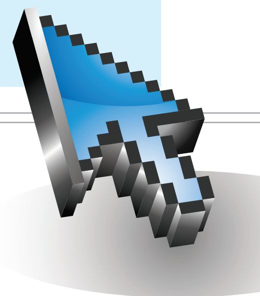
- Although turbines should be designed to last for at least 10 years service and often much more, many do not live long due to technical failures or excessive need for maintenance.
- They frequently have misleading or non-existent noise data and are not designed according to existing safety standards and have caused accidents.
- Some may even be illegal to use, because they do not fulfil legal product requirements.

Manufacturers

Choosing a wind turbine can be a daunting task for a would-be buyer. Unlike larger MW class wind turbines market, where a few major players dominate the market, there are hundreds of different manufacturers worldwide. One only needs to take a look at the website: www.allsmallwindturbines.com to see the huge range of makes and models that exist on the market. Currently the webpage has over 500 turbines listed by 190 manufacturers.

To name the manufactures from the WICO Partner countries:

ITALY	SPAIN	UK
Tozzi Nord www.tozzinord.it	Turby Ibérica (Speedwind S.L.) www.turbyiberica.com	Ampair www.ampair.com
Ropatec www.ropatec.com	Bornay Aerogeneradores www.bornay.com	Evance Wind www.evancewind.com
Svecom Energy www.svecomenergy.com	ADES www.ades.tv	Marlec Engineering www.marlec.co.uk
Jonica www.jimp.it	ECERSA www.ecersa.com	Samrey Generators & Turbines Ltd www.leturbines.com
BMP www.bluminipower.it	Obeki Group www.obeki.com	MKW Group www.mkw.co.uk
Pramac www.pramac.com	SOLENER www.solener.com	Eclectic Energy www.eclectic-energy.com
Terom www.terom.it	Indesmedia EOL www.indesmediaeol.es	Proven Energy www.provenenergy.co.uk
Aria-Libellula www.aria-srl.it	Donqi Ibérica www.donqi.nl	Renewable Devices renewabledevices.com
EolPower www.eolpower.com	Robotiker www.robotiker.es	
	Kliux www.kliux.com	
	Enair http://enair.es	
	Windeco www.windeco.es	



The only mass-produced wind turbine manufacturer identified by WICO project is SouthWest Windpower in the United States and to a lesser extent Proven in UK.

The market is less controlled than the solar PV market, and there is currently no standardisation, thus it is difficult to make comparisons between manufacturers. What usually happens is that an installer or investor works with one company that they know and have confidence in. Thus in this document, it is not possible to recommend any particular manufacturer or make for this reason. The only advice would be to follow the maxim, same as with most electronic and mechanical products, that “you get what you pay for”. The cheapest wind turbine is not likely to last many years of operation, whereas a more expensive one will probably give you 15 to 20 years of service.

Predicting Real Production - Consumer Confidence

One of the key factors responsible for the current shaky consumer confidence in small-wind turbines, is the uncertainty with regard to their real energy production. The Capacity Factor can be used as a way of predicting production based on wind turbine overall behaviour. However the best way to predict the energy production is based on the wind speed distribution and its Power Curve:

Weibull and Power Curve correlation

The correct way of quantifying the annual energy yield is to measure the wind data in situ and later analyse the results. This is normally not used, as it involves time and financial investment which may be viable for a large wind park, but is not so for a single small-wind-turbine installation.

This resulting graphical representation is called the Weibull curve. A Weibull curve is a probability distribution model that gives the % of time that the wind is expected to blow at each wind speed velocity interval or “bin”.

The Weibull curve has two main parameters: scale factor C (sometimes A) which gives us the most probable wind speed value and form factor k which shows how biased to the curve is towards the left and varies between 1 and 3. When k=2 it is known as the Rayleigh distribution, and this is often used for wind distribution calculations.

The other key graph is the turbine´s Power Curve, it shows the power production of the turbine by wind speed. The y axis variable is the production of the turbine in Watts (or kW), relative a windspeed variable (m/s) shown on the x axis.

Some manufacturers provide a Power Curve based on real test results. These can be considered accurate. Others provide Power Curves extrapolated from theoretical numerical models: these are less reliable. Similarly for wind speed distributions, the ideal is to have measured power data.

By multiplying the Weibull curve and the Power Curve we can obtain conclusions on annual energy production for a given site. This is the most accurate way to estimate annual production. It goes without saying that the more accurate the wind data and the more accurate the Power Curve provided, the more exact the annual production estimates will be. Figure 4 below, shows how we can correlate the two curves to calculate production.

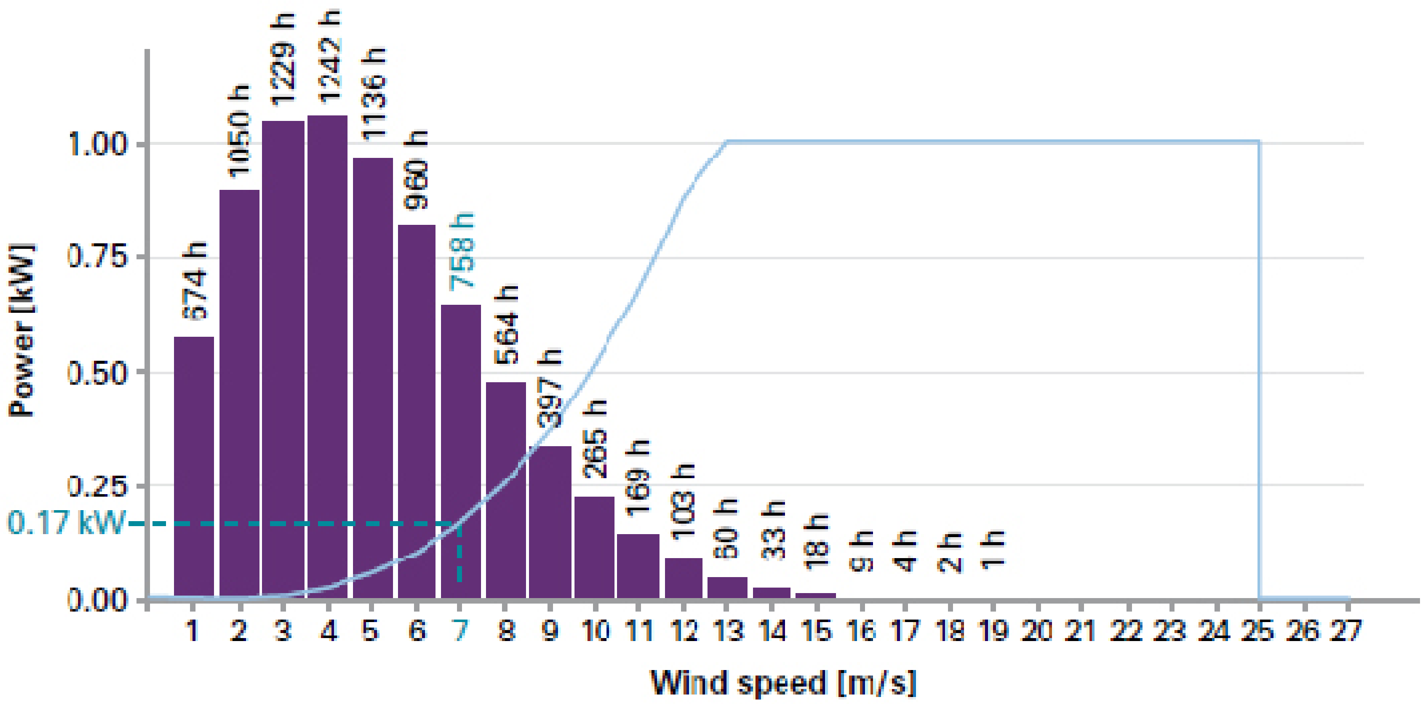


Figure 4, Calculation wind turbine production
Source: Entec from Small-scale wind energy Policy insights and practical guidance (Carbon Trust 2008)

The bars show the number of hours in the year that the wind speed is within each wind speed category. For example, shown in light blue is the number of hours at 7 m/s. From the power curve, it can be seen that the turbine would produce 0.17 kW at this speed. Multiplying the two gives 129 kWh. The sum then of all these multiplications for each wind category gives us the total annual production.

Note: Cut-in speeds are usually between 3 and 4 m/s, nominal power ratings usually between 12 and 15 m/s and cut-out speeds over 25 m/s.

Maximising wind turbine production

As can be seen in the coefficient of power equation for a turbine ($P = 0,5.\rho.Cp.A.v^3$), the key determinant for power is the average windspeed (v). The relationship between velocity and power is cubed, which means that if you increase the windspeed by a factor of 2, you can increase your instantaneous power by 8 (2^3), and so-forth.

Another key point to understanding wind power is the so named “wind shear”. Normally the wind speed increase with height with a logarithmic law, that is to say, a marked acceleration over a small distance above the ground, followed by a more gradual acceleration subsequently. The so-called shear effect gives the general rule that the higher the turbine is mounted, the greater the power that can be generated. Wind shear in urban areas begins higher due to the extra height of the natural surface caused by the buildings. Thus for roof-mounted wind turbines, height is even more critical, with an increase of hub height from 2 to 9m, we can increase energy production 3-fold.

Wind also tends to speed up over hills, and thus it is not surprising to see large turbines on high hill-tops where the highest winds are found. Hills with steep sides create turbulence at the summit, and therefore shallowly rising hills are optimal. Turbulence both reduces turbine efficiency and its lifespan. Excessive strains and stresses on moving parts can cause critical damage or wear to the mechanical workings of the turbine.

A very detailed study conducted by Met Office (Small-scale wind energy Technical Report, August 2008) in the UK showed the following results:

- A rural mounted wind turbine may achieve a capacity factor of 15-20% in the English countryside. This may be substantially exceeded if mounted near hilltops in hilly terrain, or near the coast. On the other hand, it is likely that small turbines will be mounted near houses which are more likely to be in valleys than on hilltops, so 15-20% may be a realistic typical figure.
- Suburban mounted wind turbines achieve capacity factors substantially less than this, with less than 10% being common, while urban wind turbines may achieve capacity factors of only a few percent.
- Rural wind turbines are thus generally likely to produce a much higher proportion of their nominal output than suburban, which themselves are likely to perform better than urban turbines.
- Comparing different wind turbine makes, the individual power curves have much less impact on the capacity factor than mounting height and environment.
- Urban and suburban wind turbines need to be mounted as high as possible above the mean building height.

Although it is clear that, unlike in the case of big wind, optimum locations cannot always be found, the siting of the wind turbine is absolutely key to its success.

In brief, the wind turbine should be sited, as high as financially or technically possible and away from obstacles, being sufficiently out of their wake to avoid turbulence. Where obstacles cannot be avoided as part of the environment in which the turbine is to be sited, a wind rose can be very useful to determine whether and if so where, a wind turbine should be installed.

A wind rose shows the distribution of directions and velocities of the winds throughout the year. Each spoke represents points on a compass and will indicate which are the predominant winds (see Figure 5). All small-wind turbines have a yawing system that enable the turbine to turn into the wind direction irrespective of where it's coming from; some wind turbines have active yawing systems.

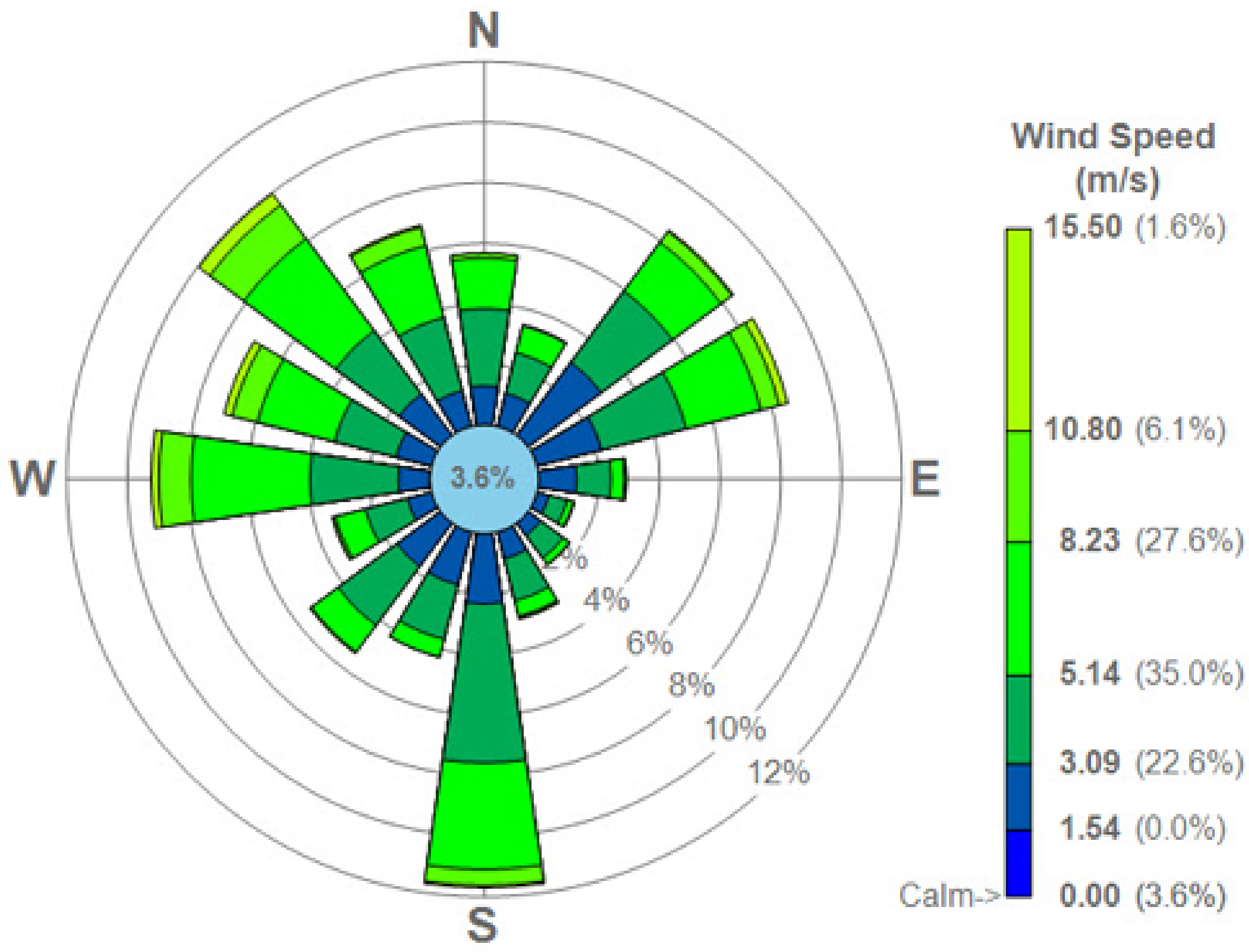


Figure 5, Example of a wind rose

Therefore, if a wind turbine is to be mounted in front of a house and cannot be raised sufficiently in height, it must at least be facing the predominant wind, so that it can capture the wind before it hits the house. However winds from other directions may not be able to be exploited due to the obstacles. If we cant even exploit the dominant wind for the obstacle then its not worth installing a wind turbine.

Wind Maps and Wind Data

Most European countries will have an organisation responsible for wind mapping, whether it be a university, the regional government, national government or other institution. They provide data and often meteorogical tools for calculating mean windspeeds and predominant wind directions, depending on the height of the turbine's hub.

With luck, your country will have data at 10m, which will be the most relevant for small-wind turbines. If not, mathematical calculations, based on height difference and surface roughness will be used to estimate the windspeeds at around 10m, or the height of the turbine.

Sources of wind data in the WICO partner countries are:

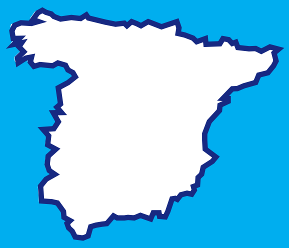
ITALY

CESI Atlas
www.ricercadisistema.it/pagine/notiziedoc/61/index.htm

Wind atlas of the University of Genova
http://atlanteeolico.erse-web.it/viewer.htm

WICO anemometers: Marino Romea (Ravenna), Lido de Danta (Ravenna), Milano Marittima (Cervia)

SPAIN



IDEA wind atlas
http://atlaseolico.idae.es/atlas

CENER wind potential analysis tool
www.globalwindmap.com

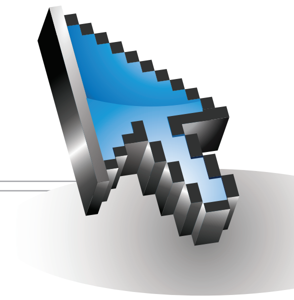
Andalusian Energy Agency wind resource map of Andalusia
www.agenciaandaluzadelaenergia.es/agenciadelaenergia/nav/com/contenido.jsp?pag=/contenidos/aplicaciones/Mapa_eolico

UK

Coastal anemometers at
www.channelcoast.org

UK Met office weather stations
www.metoffice.gov.uk/science/creating/first_steps/weather_stations.html

DECC official wind database
www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/renewable/explained/wind/windsp_databas/windsp_databas.aspx



Despite the usefulness of such databases and the information they provide, there is really no substitute for direct wind measurements in situ, especially in complex terrain. This is particularly important for small-wind, where microclimatic conditions can transform an apparently poor wind site, into a good wind location, and vice versa. Measurements for at least 6 months with an anemometer measuring windspeed and wind direction, as well as other climatic conditions, where possible, is highly recommended. With such information an accurate assessment of wind production from the relevant wind turbine can be predicted, and hence the viability of the installation.

Market Tendencies

There is much investigation underway at Universities, technical institutions and private companies to improve small-wind turbine efficiencies. However, if potential efficiency gains are limited then the reliability of the wind turbines becomes the most important issue. In addition site characteristic strongly influences the production performance of a small-wind turbine.

Lowering of the prices of small-wind turbines is one of the issues which must be overcome. Currently they could be considered relatively expensive compared to the amount of energy they can produce. But without mass scale production, this is to be expected. The problem is that without sufficient demand there will be insufficient supply to allow for possible economies of scale, but without price reductions, coupled with shaky consumer confidence, it will be difficult for demand to increase sufficiently to have an effect on the market.

Feed-in-tariffs and other financial incentives can help to encourage demand, and thus stimulate supply. However they are often linked to very expensive accreditation schemes (e.g. Micro-generation Certification Scheme in UK). This can work to reduce costs if economies of scale lead to reduction in costs, but the relationship between the two variables is not always certain.

Therefore, some increases in wind turbine efficiencies are to be expected, and depending on the behaviour of demand, costs reductions in the next few years are possible but not certain.

Policy Initiatives

D1. Provide basic training for municipal and regional officers in optimizing small-wind performance

As identified in the Administration Section (page 19), insufficient knowledge on small-wind installations and a lack of training available, mean that municipal and regional administrations are not correctly informed on the technology, its performance and its impacts vs benefits.

Therefore as performance of installations is key for successful development of small-wind, the public sector should be aware of what an installation involves in terms of permitting and potential impact on the municipality. It would be bad for the customer, bad for the wind industry, bad for Society and the Environment to see poorly operating wind energy systems spread throughout the territory.

There should therefore be adequate information and training provided at local or regional level, either directly for planners or for the energy or climate change staff. If not trained directly, the planners should be obliged to consult and coordinate with the energy/climate change team to ensure that the best advice is heeded, before approving any specific installation.

The training should take into account:

- Turbine Height paradox: The higher the wind turbine, the better performance, yet the higher the wind turbine the bigger the visual impact. Thus permitted elevation should be a balance that takes both aspects into account for distinctive planning zones (suggested height limit of over 11m to assure best use of resource).
- Correct Siting: Wind Direction and Obstacles: The turbine should be placed directly facing the prominent wind direction avoiding obstacles and turbulences. To maximise return on investment and carbon savings, wind turbines should be installed in locations as rural or suburban as feasible, i.e. hill-top sites rather than valleys, open countryside rather than forested, isolated buildings rather than villages or towns, city suburbs (within a few 100 m) rather than the city centre.
- Structure: Planning and the structural integrity of the supporting building must be checked to ensure support structure strength. The performance of a wind turbine will be compromised if it is smashed in multiple pieces on the ground.

TAKE THE TRAIN

The RuralRES project (contract nº IEE/07/797/SI2.499715 of the Intelligent Energy for Europe programme) has developed a training package in small wind power. It includes a good practices guide, a main training unit document, and a web-based package with small wind information aimed to provide crucial information for municipal officers and technicians, future experts, installers, students and all actors in renewable energy.

The Good Practice Guide contains examples of 15 Good Practices from across the EU27 demonstrating a mixture of commercially viable and replicable installations, innovative applications and financing methods, commercially successful operations, farm-scale operations, roof-mounted and ground mounted turbines, off and on-grid systems and professional and DIY systems.

The Main Training Unit Document contains information on: Background; Current Situation Of Small Wind Energy; Perspectives; Wind Energy Resource And Its Potential; Regulatory Framework; State Of The Art; Advantages And Drawbacks; Types Of Wind Turbines; Wind Turbine Components; Other Components Of A Wind Energy System; Energy Produced; Economic Aspects; Installations And Applications Of Small Wind Energy Systems ;Wind Energy In Urban Areas; How To Undertake A Pre-Feasbility Study

These documents and the other supporting files and tools are all available at the following link: http://ruralres.diphuelva.es/formacion.php

Box 6, RuralRES training package

D2. Require Production Predictions

Any planning application should require a production estimation from the customer, investor or installer to demonstrate the viability and validity of the project. Having thousands of small-wind installations in a municipality, none that produce any energy is not good publicity and does not provide the benefits that outweigh any impacts that the installations may create.

This could also provide a useful tool for any energy audits and emissions inventory that a municipality may be carrying out as part of the Covenant of Mayors initiative or other such programme, and that they can include as part of their 20-20-20 targets.

D3. Introduce accreditation schemes for wind turbines

The introduction of accreditation schemes for small-wind turbines will be done at national/international level, but could be the key for promoting consumer confidence. The accreditation should be based on the real production of the wind turbine, accompanied with manufacturers warranty and standards for safety and noise. It should ensure:

- A long and reliable operational life, absent of technical failures and excessive maintenance.
- Performance declared by a published power curve.
- Reliable noise data.
- Manufacturing process in compliance to the international standards.

An example of such a scheme is the MCS in the UK shown in Box 7:

RAISING THE STANDARDS

The UK's Microgeneration Certification Scheme (MCS) is a third party certification scheme for microgeneration products. The scheme has been developed to build consumer confidence by ensuring quality and reliability. It has a wide scope of services covering accreditation for wind turbine manufacturers, products, and installers, and includes general assistance and information for potential customers.

Only those products and installers certified under MCS are eligible for the UK's Feed-in tariffs. The aim is that certification will be widely used by manufacturers and installers to ensure customers can obtain financial support to buy their products and services.

This scheme provides ongoing independent, third party assessment and approval of companies who wish to demonstrate that their micro and small wind turbines with rated electrical power outputs up to 50 kW (measured at a wind speed of 11.0 m/s) meet and continue to meet the requirements of the British Wind Energy Association Small Wind Turbine Performance and Safety Standard (29 February 2008). This standard is available at: www.bwea.com/pdf/small/BWEA_SWT_Standard_Feb2008.pdf. Inter alia the standard for the MCS is based on:

- *BS EN 61400-12-1:2006 for wind turbine performance. Wind turbine performance shall be tested and documented in a test report.*
- *BS EN 61400-11:2003 for acoustic noise. Acoustic noise emission gathered simultaneously with wind speed shall be measured in general accordance.*
- *BS EN 61400-2:2006 for design: According to the specified design requi rements of small wind systems.*
- *BS EN 61400-2:2006 for mechanical strength and reliability.*

To get approval and certification a manufacturer must show that the product meets the standards and that the manufacturer has staff, processes and systems in place to ensure that the product delivered meets this standard. They must also agree to periodic audits including testing as appropriate and compliance with the contract with the certification body including agreement to rectify faults as appropriate. A full set of documentation must be submitted for review to demonstrate all the above.

This process, of course, can lead to high additional costs for manufacturers. In fact it has been estimated that costs for testing can be as much as 200.000 €, which for small manufacturers could prove unviable if the extra costs are not balanced out by an increase in business.

Box 7, Microgeneration Certification Scheme in UK

These accreditation schemes can be very expensive for manufacturers and this will undoubtedly have its impact on wind turbine prices. The cure could in fact result worse than the disease, in that, to stimulate small-wind installations we introduce an accreditation scheme to ensure consumer confidence and increase demand, but the increased costs associated render the investment in small-wind turbines prohibitively expensive, and demand decreases. Thus, where possible, any accreditation scheme must be as financially accessible for manufacturers, as possible.

D4. Introduce accreditation scheme for installers

An accreditation scheme for installers can be set up at a regional level. Installers will have to meet with certain requirements based on competencies, safety, guarantees and legality. This list of accredited installers could be published on a website and published for access by the general public. Any grants provided will be linked only to installations by accredited installers. This type of scheme works in Andalusia in the PROSOL accreditation scheme (see Box 8):

SATISFACTION GUARANTEED

The PROSOL Andalusian grant scheme has already been mentioned in Box 5. A very important part of this scheme has been the accreditation of installers to make sure that correct protocols are adhered to and that the grants are correctly and intelligently distributed. Supported installations must be carried out by accredited installers of the PROSOL scheme, of which there are currently 1214. To make sure the installations are eligible for the grants, the accredited installers must be able to guarantee correct functioning of the system and a 3 year maintenance guarantee with no extra cost to the customer. The accredited installers are also enabled to inform and process the application for installations on behalf of customers thereby saving them unwanted paperwork.

In brief the accredited installers must adhere (inter alia) to the following:

- *Undertake installation and repairs according to the relevant norms and regulations.*
- *Meet with all the relevant standards for components of the system.*
- *Inform the customer of the requirements for PROSOL before contract*
- *Ensure a minimum of 3 years guarantee free of charge*
- *Be at the disposition of the Andalusian Energy Agency (AAE) for checks*
- *Make it clear at site that the installation was supported by the scheme*
- *Provide technical and financial information to the AAE when required*
- *Ensure that installation complies with Building Regulations (RD 314/2006)*
- *Cooperate with AAE to facilitate telemonitoring at certain installations*

Box 8, PROSOL accreditation scheme in Andalusia

D5. Assist consumer-choice by hosting a website with information on products etc

A product accreditation scheme will have to be instigated at the national level, but there are associated initiatives at the local and regional level that could implemented. The local/regional government could set up a website providing a list of the accredited products, accredited installers etc. They could also distribute leaflets on accreditation. With the aim of enabling the general public and would-be investors to understand the accreditation scheme and to make informed purchase decisions.

Such a website could also include a list of Dos and Donts:

- For Model selection, providing a proposed decision-making process with the factors to take into account.
- Advice on correct siting of the wind turbine.
- Advice on security measures.
- Information on minimizing impacts for neighbours etc.

D6. Investigate public procurement options for small-wind turbines

Small-wind turbines are often purchased by private individuals, without the professional competence and procurement practices normally used when buying medium and large wind turbines. If the Administration were able to find ways of collective procurement in their territory, this could help reduce costs for private investors. If this is not feasible, at least the Administration, could bulk-buy for its own installations, helping manufacturers and helping market penetration in its territory.

Technical Progress

This photo is of the Hydriada experimental wind turbine for desalination being trialled in the Aegean Sea, Greek Islands

Small-wind turbines market could be considered to be an immature market. The future of small-wind turbines is mainly dependent on three aspects:

1. Capability to improve small-wind turbines reliability.

2. Capability to decrease small-wind turbines cost for energy produced - €/kWh - (technological improvements).

3. Capability to widen as much as possible small-wind turbines applications in different environments and improve sales prospects.

Reliability

Small-wind turbines have been developed based on 3 different R&D concepts:

1. Aesthetical approach: R&D stemming from the market requirements. Results show that these products are attractive but not smart, that means that they can be installed in many sites because they have nice appearance but they have low efficiency.

2. Cost approach: There is no real R&D and production begins from economic/cost requirements. Results show that these products are cheap but their reliability and safety inadequate.

3. Technological approach: R&D is driven by reliability requirements. Features of big wind turbines (wind turbines are designed according to the IEC norms that requires: structural and aerodynamic calculations/simulation, duration tests, reliable suppliers, etc…) are copied and customized for small-wind turbines. Results show that these products are reliable but few units have been manufactured and sold as of yet.

Technological Improvements

Wind turbines design can be divided into the following items, and where advances and improvements are to be expected in the coming years:

- Power train: Grid connected wind turbines have many power train configurations varying from full variable with no gear (100% power passing through the inverter) to the synchronous generator directly connected to the grid. Up to now due to the small numbers of small-wind turbines sold, small-wind turbines manufacturers use standard products that once production numbers increase, could be customized and optimized for small-wind.
- Mechanical components: The main problems are related to the mechanical customized components manufactured by workshops and to the bearings. In the first case depending upon the number of small-wind turbines, different techniques with different investment/final product cost ratio must be considered. In the latter case, bearings, especially for the yaw and pitch system, are one of the most critical components. Wind turbines have a peculiar operational range for bearings and bearing manufacturers have only recently developed specific bearings for turbines but these are mainly for large wind turbines.
- Power conversion electronics: These products are quite similar to the ones for PV applications. One of the main critical items is compliance with grid requirements and norms. At present there are few products that are certified according to all the different international protocols.

- Control system: In pitch regulated wind turbines an optimized control strategy can dramatically reduce the loads. Due to this fact, big wind turbine manufacturers dedicated a lot of attention to this topic thanks to the availability of simulation tools such as aero-elastic code and on-board electronics in terms with high calculation performances. These tools and strategies are rarely transferred to small-wind turbines segment due to the high investment costs in personnel know-how.
- Aerodynamics: For horizontal wind axis turbines (HAWT) specific blades profile have been available for the last 15 years. This profiles were optimized for large wind turbines and are now being progressively transferred to small-wind turbines. The difficulties are in catching profiles performance for low Reynolds numbers that are typical for small-wind turbines. Aerodynamics of vertical axis wind turbines (VAWT) is peculiar therefore its development is specific. One of the research centres specialising in this field is Delft University.
- Remote monitoring: This system is very powerful whenever the manufacturer wants to focus on high quality service. It must be pointed out that few small-wind turbines have this system available nevertheless the know-how in this field is quite advanced. The highest cost of this system is actually its monitoring activity (trained personnel) rather that the initial investment. Monitoring is recommended for all installations, which will lead to accelerated technological development.
- Stand-alone options: This type of application requires its own development based on energy storage equipments and power conversion electronics, etc. We expect to see some step-changes in battery storage technologies that could greatly improve cost-efficiencies.

Increased Applications

Applications for small-wind turbines can be split into two main categories:

- Stand-alone off-grid installations.
- Installations connected to the grid.

Applications for stand-alone off-grid installations:

1. Electrification of isolated housings, equipments and public services. Housings in isolated sites.

2. Mountain refuges, points of observation, electrical fences, etc...

3. Electrical supply to small agricultural or industrial isolated facilities.

4. Water pumping by energy supply for the pump or by accumulation of the electricity in batteries, for irrigation, lighting of greenhouses or farms, milking systems, refrigeration, etc.

5. Desalination and water treatment in small-scale plants.

6. Telecommunications equipment, lighting, maritime signaling, lighthouse, repeaters for radio, television and telephone, alarm devices, etc...

7. Drying of flood plains.

Applications for installations connected to the grid:

8. Total sale of the electricity produced to the grid.

9. Simultaneous sale and consumption of electricity. (Net-metering).

Other applications:

10. Production of hydrogen (H_2).

11. Water pumping by the direct use of the mechanical energy supplied by the wind turbine.

12. Obtaining thermal energy. The mechanical energy of a wind machine could be transformed directly into thermal energy through two mechanisms: water heating by mechanical friction or compression of the cooling fluid by a heat pump. In both cases, the produced heat can be sent through a heat exchanger to a conventional heating system. Nevertheless, the development of this type of application is normally not economically feasible. It is normally better to generate electricity than to build a wind system only for thermal application.

Other applications:

For some examples of small wind turbine applications, you can refer to the RuralRES project Good Practice Guide available at the RuralRES website. The Guide contains examples of 15 Good Practices from across the EU27 demonstrating a mixture of commercially viable and replicable installations, innovative applications and financing methods, commercially successful operations, farm-scale operations, roof-mounted and ground mounted turbines, off and on-grid systems and professional and DIY systems (see Box 6).

Whilst more innovative uses are found, more investment and technological improvements are to be expected to follow. As the technology is not a mature one, there is still a great scope for technical progress in all the aforementioned areas, which coupled with cost reductions could lead to an accelerated uptake for small-wind installations.

Policy Initiatives

T1 Install innovative designs in municipalities

Installing innovative turbines or innovative applications, such as vertical axis wind turbines, or other less trialled systems could provide useful case studies to measure and monitor performance of newer technologies. Where financial payback is not the objective it gives the public sector the possibility to trial systems that the private sector would not. It is always recommended to undertake such trial installations in collaboration with universities or technical training centres to ensure full use is made of the trial to maximise knowledge gain. It could be combined or linked directly to Policy Initiative S6 for educational purposes.

T2 Invest in ideas- local innovation technology development programmes

This could take the form of programmes or competitions for best designs or most innovative ideas for small wind technology and its applications. The idea is to use the local entrepreneurial and technological talent to develop local initiatives that could further be developed if the ideas or projects prove viable. Many depressed regions in the EU are looking for products that can be developed locally and small-wind turbine manufacture could offer opportunities for local talent.

T3 Provide monitoring equipment for existing installations

One of the big issues facing small wind turbine industry is, as mentioned previously, the shaky consumer confidence, and in some cases this is not ill-founded. There is no standardisation yet in most countries and manufacturer-provided Power Curves are often misleading. Thus monitoring of existing local installations would show how different makes and models are performing in your specific territory. A public database, with data from the installations could prove extremely useful in establishing the dos and donts for installations and in building confidence in the medium term by establishing the best practices for small wind in your locality or region.

T4. National R&D Investment

This would require involvement of the State organisations or large universities. A testing ground of all national and international makes and models where feasible, could provide invaluable information on performance of small-wind turbines. Testing, monitoring and development of national standards would be the goals of the R&D centre. In fact, in Spain an R&D centre for small-wind has already been set up by CENER-CIEMAT and is briefly presented in Annex A. Replication of such centres across the EU would be highly beneficial and could prove a real driver in stimulating the small-wind turbine market, filling the research and standardisation gaps that currently exist.

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European Union European Regional Development Fund

ANNEXES

ANNEX A

The Centre for the Development of Renewable Energy (CEDER), located a few kilometres from Soria, was created in the 1980´s as a national centre for research, development and promotion of renewable energies. As member of CIEMAT and as part of its Energy Department, it is considered a pioneering centre in Spain in the field of biomass and is now a national a European reference point for miniwind technology. This installation or group of installations is a best practice for technological development at the national level. Principle activities in miniwind currently focus in three areas: Off-grid miniwind; Flywheel testing; Power production measurements. Other functions of the centre are to inform technicians and the public through group educational visits.

CIEMAT managed to achieve financing through FEDER funds to complete the instrumentation for small scale wind generator trials being undertaken in CEDER. It was a challenge as many turbines need to be measured simultaneously. The funds covered noise emission measurement systems, and the data collection software. The approval of this project PSE-Minieolica, comes under subproject 3.1 for the Measurement and Trial of national small wind technology being developed in the CEDER-CIEMAT plant. They are also monitoring hybrid wind (10kW) and photovoltaic (5kWp) and diesel (16kW) systems through battery bank storage and controlled through a system called CICLOPS developed by the company Ecotecnia and financed by the Ministry of Science and Technology through the PROFIT programme. It aims to study and improve conversion technologies for AC-DC and DC-AC.

The programme to research small wind turbines (1-50kW) has two trial plants- PEPA I and II.

PEPA I

This installation includes, amongst other equipment, a meteorological tower at 100m with wind speed and direction measures a 5 height levels, 3 trial towers for small turbines along with monitoring equipment, as well as testing areas for components and for particular applications like water pumping.

PEPA II

Amplification of the off-grid trial area, focused on turbines of greater power (10-15kW). It consists of a metereological tower 40m, 4 towers of between 12m and 24m, and 4 trial points for wind turbines, with data collection equipment. It has both battery banks and connection to the grid.

PEPA III

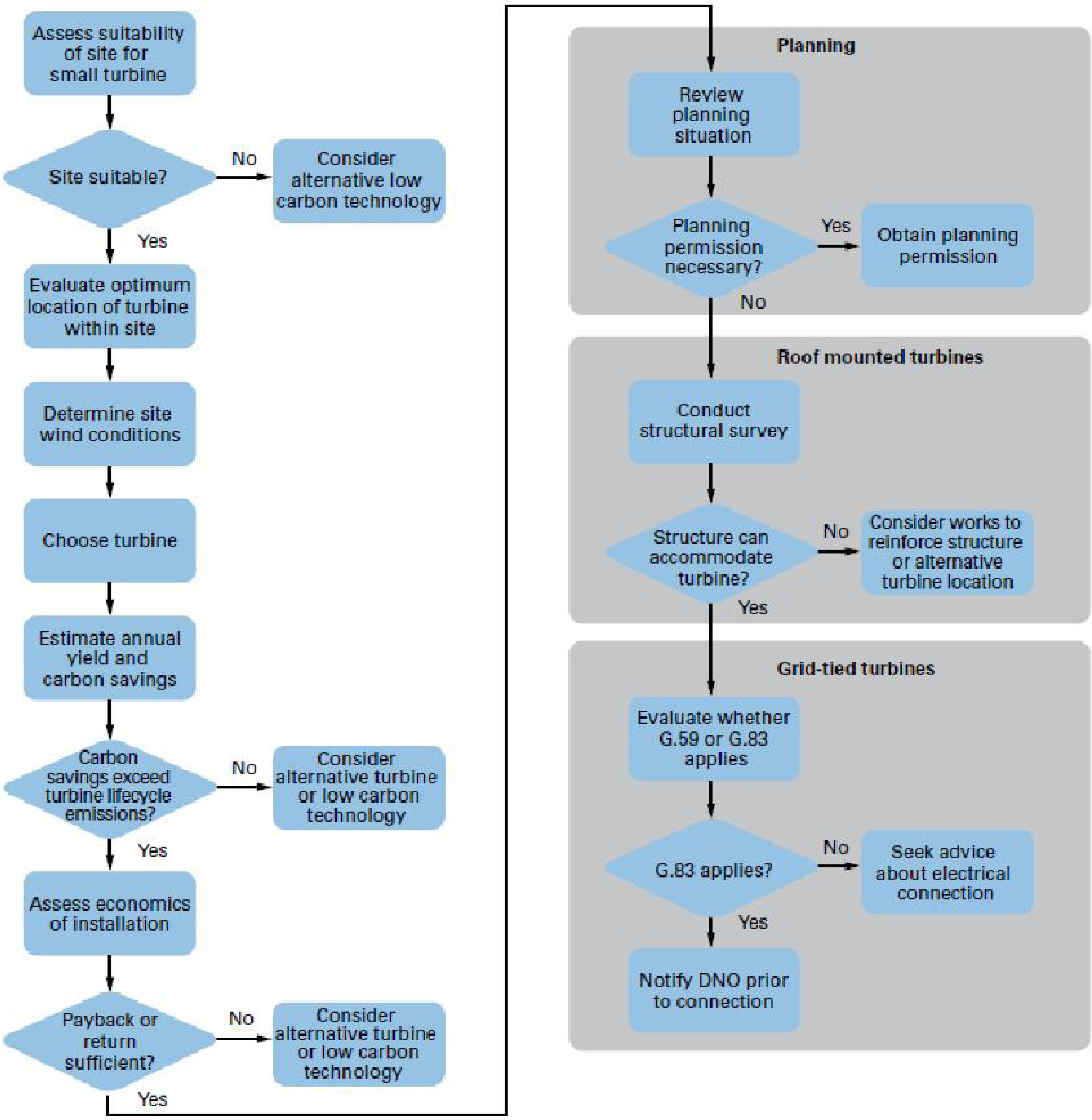
Recently constructed and is foreseen to measure larger turbines of between 50 and 100kW. So far a new ADES 1- blade turbine of 250kW has been installed. It includes a trial laboratory for Flywheel testing(LEVI) which is unique in Spain. It is equipped to trial all types of rotating parts up to 63000rpm with modular equipment to trial rotors and other components. The system allows trials for the fatigue cycle, over-velocity trials and stress limits for metal and other materials.

The public sector and scientific research institutes have a key role to play in demonstration, and technical progress in this area. Such trials could be replicated in all EU countries, to give a boost to miniwind technology and encourage investment.

More information is available at: http://minieolica.ciemat.es/MINIEOLICAportal

ANNEX B

Flowchart demonstrating a transparent planning process



Source: Small-scale wind energy. Policy insights and practical guidance. Carbon Trust 2008.

ANNEX C *By-Law Example (Source: CANWEA)*

Section 1. Intent and Purpose

It is the purpose of this regulation to promote the safe, effective and efficient use of small-wind energy systems installed to reduce the on-site consumption of utility-supplied electricity, while providing reasonable controls to protect public health and safety without significantly increasing the cost or decreasing the efficiency of a wind energy system.

The [City/Region] of ___________ recognises that privately-owned small-wind turbines are non-polluting, help reduce ___________'s reliance on fossil fuels, help reduce public utility electrical demand and contribute to the efficiency of the utility grid.

The [City/Region] of _________ further recognises that small-wind turbines are substantially different from commercial wind farms and from commercial cellular or radio towers as they are designed to supply electrical power for the owner and are not typically revenue-generating ventures. The much larger scale wind turbines and wind farms intended to sell energy directly to power companies or retail users are not covered by this Local Land Use Guideline and will be addressed independently.

This regulation requires the [City/Region] of ____________ to approve an application for a small-wind energy system by right if the criteria below are met, and authorises the local agency to charge a fee of not more than fifty dollars ($50) per small-wind energy system. If any portion of the proposed small-wind system does not meet the requirements set under this Local Land Use Guideline, a zoning variance will be required. No other local ordinance, policy, or regulation shall be the basis to deny the siting and operation of a small-wind energy system.

Section 2. Findings

The [Municipality] finds that wind energy is an abundant, renewable, and nonpolluting energy resource and that its conversion to electricity will reduce our dependence on nonrenewable energy resources and decrease the air and water pollution that results from the use of conventional energy sources. Distributed small-wind energy systems will also enhance the reliability and power quality of the power grid, reduce peak power demands, and help diversify the local energy supply portfolio. Small-wind systems also make the electricity supply market more competitive by promoting customer choice.

The [Province] of ___________ has enacted a number of laws and programs to encourage the use of smallscale renewable energy systems including rebates, net metering, property tax exemptions, and other incentives [as appropriate]. However, many existing local zoning ordinances contain restrictions, which while not intended to discourage the installation of small-wind turbines, that can substantially increase the time and costs required to obtain necessary construction permits.

Therefore, we find that it is necessary to standardise and streamline the proper issuance of building permits for small-wind energy systems so that this clean, renewable energy resource can be utilised in a cost-effective and timely manner.

Section 3. Definitions

- **Small-wind Energy System:** A wind energy conversion system consisting of a wind turbine, a tower, and associated control or conversion electronics, which has a rated capacity of not more than 300 kW, and which is intended to provide electrical power for use on-site (either behind the meter or off-grid) and is not intended or used to produce power for resale.
- **Turbine:** The parts of a wind system including the rotor, generator and tail.
- **Total System Height:** The height from ground level to the tip of the rotor at its highest point.
- **Wind Turbine Tower:** The guyed or freestanding structure that supports a wind turbine generator.
- **Wind Turbine Tower Height:** The height above grade of the fixed portion of the wind turbine tower, excluding the wind turbine and rotor.
- **Off-grid:** A stand-alone generating system not connected to or in any way dependent on the utility grid.
- **Behind the meter:** A generating system producing power for use on a grid-connected property, but which system may or may not be capable of sending power back into the utility grid.

Section 4. Permitted Use

Small-wind energy systems shall be a permitted use in all zoning classifications where structures of any sort are allowed; subject to certain requirements as set forth below:

4.1 Wind Turbine Tower Height

It is recognised that small to medium wind turbines generally require tower heights of 24-50 m (80-164 ft) to reach wind currents reasonably adequate to generate energy. For property sizes between 0.1 ha (0.25 acre) and 0.2 ha (0.5 acre), the wind turbine tower height shall be limited to 80 ft (25m). For property sizes of 0.2 ha (0.5 acre) or more, there is no limitation on wind turbine tower height, subject to the set-back requirements below, and provided that the application includes evidence that the proposed height does not exceed the height recommended by the manufacturer or distributor of the system.

4.2 Set-back

The turbine base shall be no closer to the property line than the height of the wind turbine tower, and no part of the wind system structure, including guy wire anchors, may extend closer than three (3) m (10 ft) to the property boundaries of the installation site. Additionally, the outer and innermost guy wires must be marked and clearly visible to a height of 2 m (6 ft) above the guy wire anchors. The City/Region Board may waive setback requirements from adjacent properties if such adjacent property owner agrees to grant an easement binding on the current and future owners.

4.3 Sound

The mean value of the sound pressure level from small-wind energy systems shall not exceed more than 6 decibels (dBA) above background sound, as measured at the exterior of the closest neighbouring inhabited dwelling (at the time of installation or during operation), for wind speeds below 22 mph (10 m/s) and except during short-term events such as utility outages and/or severe wind storms. Applicants may apply for exemptions from this requirement with written authorisation from the pertinent building owner(s) and tenants, if applicable.

4.4 Approved Wind Turbines

Small-wind turbines must be approved by a small-wind certification or qualification program recognised by the Canadian Wind Energy Association.13.

4.5 Compliance with International Building Code

Building permit applications for small-wind energy systems shall be accompanied by standard drawings of the wind turbine structure, including the tower, base, and footings, anchoring method and drawn to scale. An engineering analysis of the wind turbine tower showing compliance with the International Building Code and certified by a licensed professional mechanical, structural, or civil engineer shall also be submitted. Documentation of this analysis supplied by the manufacturer shall be accepted. Wet stamps shall not be required.

4.6 Compliance with Air Traffic Safety Regulations

Small-wind energy systems must comply with applicable air traffic safety regulations. A statement on compliance by the applicant is sufficient. Transport Canada must be notified of the location (latitude and longitude) and height of all wind turbine installations through the aeronautical clearance application process. Small-wind turbine towers shall not be artificially lighted except as required by Navigation Canada.

4.7 Compliance with Existing Electric Codes

Building permit applications for small-wind energy systems shall be accompanied by a line drawing of the electrical components in sufficient detail to allow for a determination that the manner of installation conforms to existing electrical codes, if applicable. This information frequently is supplied by the manufacturer.

4.8 Utility Notification

No grid-intertied small-wind energy system shall be installed until evidence has been given that the utility company has been informed of the customer’s intent to install an interconnected customer-owned generator. A copy of a letter to the applicant’s utility is sufficient. No response or evidence of approval from the utility is required. Off-grid systems and grid-tied systems that are not capable of feeding onto the grid with advanced control grid fault protection and disconnect switches covered under the electrical code shall be exempt from this requirement. If the proposed small-wind energy system meets the above criteria, the [Municipality/Region] shall approve an application for the small-wind energy system by right without a public hearing. For those proposed small-wind energy systems that do not meet the above criteria, a zoning variance will be required.

Section 5. Severability

If any provision of this Ordinance shall be held to be invalid or unenforceable for any reason, the remaining provisions shall continue to be valid and enforceable.

Source: © 2006 Canadian Wind Energy Association.