COST Action TU1304: WINERCOST
International Training School, Malta

Advances in Wind Energy Technology

Challenges in the Implementation of Wind Energy Technology in Malta

Cyril Spiteri Staines, Ruben Paul Borg

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Challenges in the Implementation of Wind Energy Technology in Malta

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History of Wind Energy in Malta

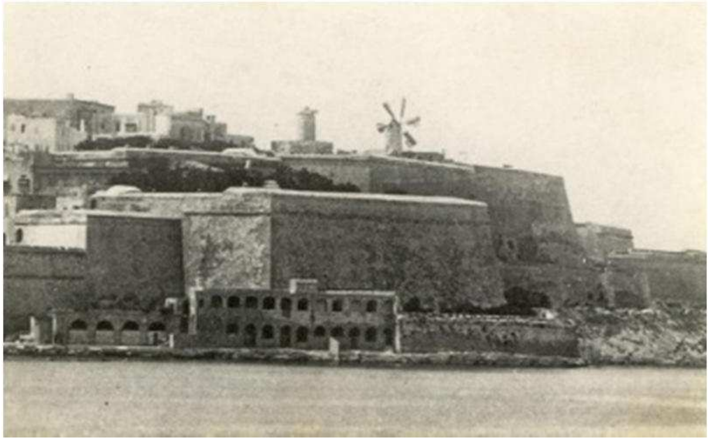
History of Wind Energy in Malta

Ta' Kola Windmill (Gozo) with surrounding open space.

Stone Masonry Windmills

- Corn Grinding mills for the Production of flour. The first Corn grinding mills were driven by animals.
- Construction of Windmills: 16th century.
- Windmills constructed in stone masonry in the 16th Century in Malta after the arrival of the Knights of the Order of St John in 1530. (c. 37 windmills)
- The first were constructed in Senglea in the Grand Harbour in 1532 by Grand Master L'Isle Adam (1530-1534) and at Fort St Elmo in 1582.
- Grand Master Nicolas Cotoner (1663-1680): 10 windmills.
- Grand Master Gregorio Carafa (1680-1690): 10 windmills.
- Grand Master Ramon Perellos y Rocafull (1697-1720): 3 / 4 windmills.
- Grand Master Manoel de Vilhena (1722-1736): 8 / 9 Windmills.

Stone Masonry Windmills



Windmills perched on the high Bastions of Valletta

Stone Masonry Windmills

- New windmills constructed in stone masonry in the 19th Century in Malta during the British Period (c. 38 windmills).
- Increase in animal driven grinding mills which could be operated for longer periods. c.1860 .
- Increased competition led to operational difficulties for the windmills.
- Introduction of steam driven grinding mills led to a sharp decline in the operation of windmills.
- Introduction of fuel operating grinding mills in the mid 20th century.

Stone Masonry Windmills

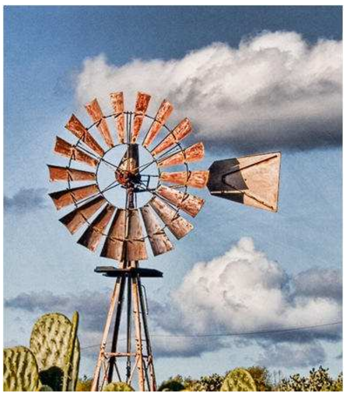
Stone Masonry Windmills

- Windmills constructed on high ground and open space close to the villages.
- Exposed ground, high on the bastions in the Cities.
- Stone masonry structures, consisting of three or more storeys: Two storey base with a rectangular plan and a cylindrical structure on top supporting the 6 sails.
- Rectangular, Circular or Octagonal base stone masonry structure.
- External Timber structure to support the sails.
- Internal Timber structure and mechanism, grinding stone.

Water pumps

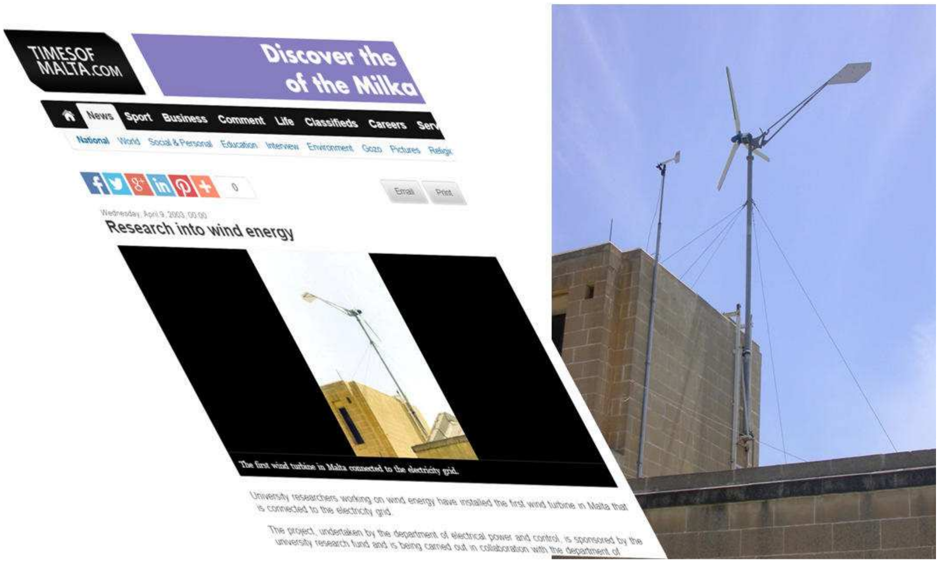
- Chicago windmill (Raddiena) Water pumps: micro-scale.
- Have been used for irrigation in rural Malta: 20th Century.
- 300 windmills were listed across Malta and Gozo in 2001. Farmers replaced the windmill with electric water pumps: deteriorating windmill steel structures.
- Ministry for Resources and Rural Affairs – University of Malta project: upgrading the rotor design structure's aerodynamics to improve water-pumping efficiency and maintain the original visual appearance of a multi-bladed rotor.
- Grid-connected turbine producing electricity: clean energy

Water pumps



Grid Connected Local Micro-Wind Turbines

First Grid Connected Horizontal Axis Wind Turbine of the Maltese Islands - UoM Research (installed in 2003)

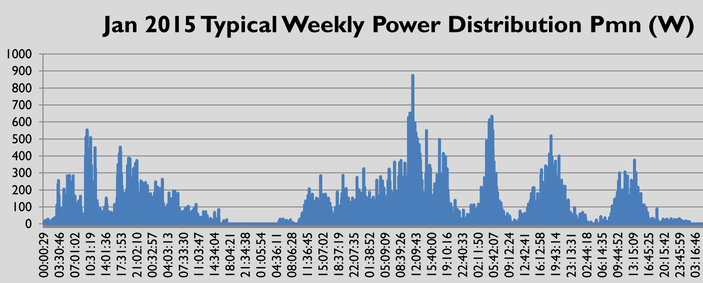


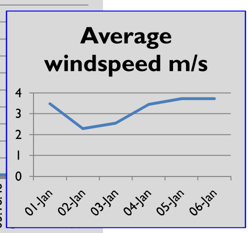
Research was conducted on….

- Site: Roof mounted 1.5kW HAWT
- Research focus on :
  - protection against 'run-away' condition during grid-failure.
  - Design of 'flexible' inverter d.c. link i/p for simultaneous p.v. and wind connection.
  - Mechanical alteration to furling mechanism
- Also to monitor public perception to issues such as:
  - Visual impact
  - Day-Light flicker – particularly to neighbouring buildings
  - Noise and vibration

First Operational Vertical Axis Wind Turbine in Malta UoM Research (2011)

- Site : Roof mounted 3kW VAWT Enervolt
- Savonious Type (Drag Type)
- This turbine was found to yield a very low power output as can be seen from the below power curves
- On-going research to improve the power conversion stage for better power point tracking.





Possibly Largest Wind Turbine in Malta

- Horizontal Axis
- Requested Power 15kW
- Site: Cirkewwa Ferry Terminal
- Date: 2012

Other Local Micro-Wind Turbine Systems

Ref.	Location	Location	Manufacturer	Axis	Power (kW)	Year of Installation	Remarks
1	University Horizontal Axis	Msida	Fortis	Horizontal	1.5	2003	Urban Area
2	University Vertical Axis	Msida	Enervolt	Vertical	3	2010	Urban Area
3	Xrobb il-ghagin Horizontal Axis	Xrobb il-Ghagin	Proven	Horizontal	6	2008	Non-Urban
4	Xrobb il-ghagin Vertical Axis	Xrobb il-Ghagin	Aeolos	Vertical	6	2008	Non-Urban pending Tech. Issues
5	Enemalta - Vendome, Ramlet il-Qortin	Mgarr	Proven	Horizontal	2.5	2008	Non-Urban
6	Cirkewwa Ferry Terminal	Cirkewwa	n/a	Horizontal	15	2012	Non-Urban
7	Wasteserv (Luqa)	Luqa	Proven	Horizontal	2.5	n/a	Non-Urban
8	Wasteserv (Hal Far)	Hal Far	Proven	Horizontal	2.5	2008	Non-Urban
9	Wasteserv (Mrieħel)	Mrieħel civic amenity		Horizontal	1	2008	Urban

Others….

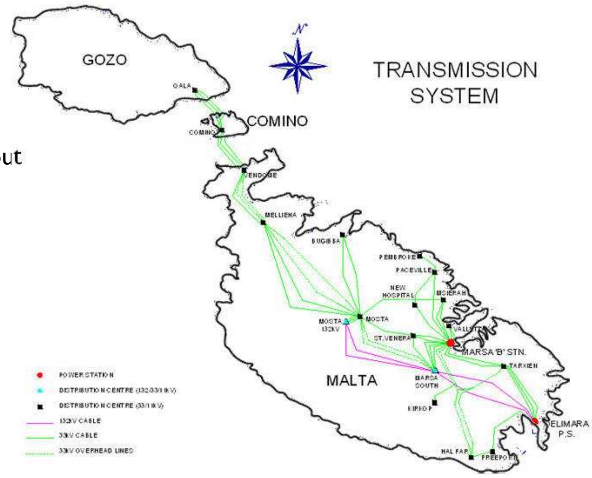
Ref.	Location	Location	Type	Axis	Power (kW)	Year of Installation	Remarks
11	Naxxar – Solar Solutions – Tal-Balal	Naxxar	Fortis	Horizontal	n/a	n/a	Non-Urban
12	Balzan – San Anton	Balzan	n/a	Vertical	n/a	n/a	Urban
13	Pembroke Primary School – Vertical Axis	Pembroke	Helix	Vertical	2/ 4.5	n/a	Urban
14	Wasteserv	Mriehel	Helix	Vertical	2 /4.5	n/a	Urban
15	Chicago Wind Turbine	n/a	UM	Horizontal	n/a	n/a	Under Design Phase
16	Smart City – Lamp Posts	Smart City	n/a	Vertical	<1	n/a	-
17	Ta'Qali - Parks	Ta' Qali	Recowatt	Vertical	≈0.3	n/a	Non-Urban
18	Naxxar GS Roundabout	Naxxar	Bergey	Horizontal	≈0.3	n/a	Urban
19	Gozo Econotechnique	Gozo		Vertical	n/a	n/a	Non-Urban

Summary:
Urban Wind Turbine = 2 HAWT and 5 VAWT
Non-Urban Turbine = 5 HAWT and 3 VAWT

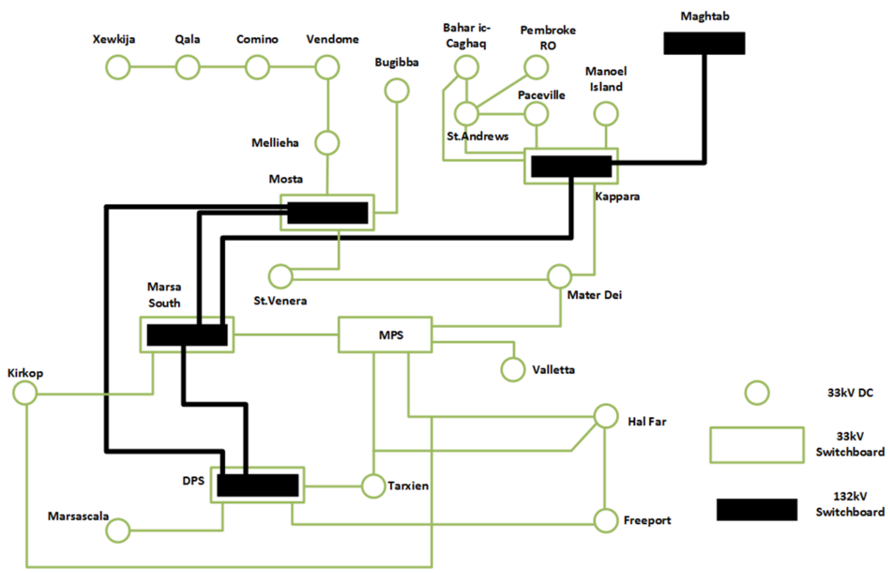
Large Scale Grid Issues for the Maltese Islands

Simulation and Analysis of 100MW Wind Farm for Malta

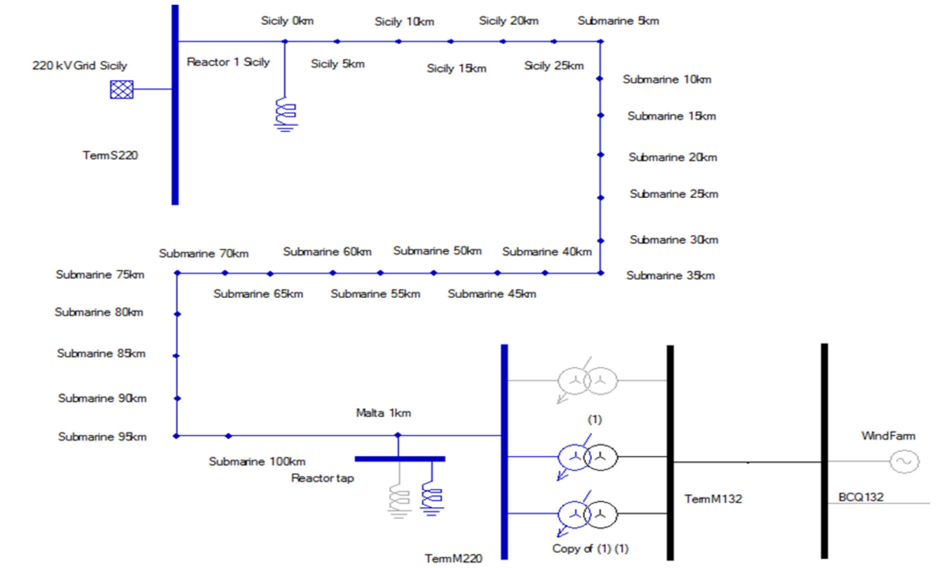
Results of Project carried out by Electrical Engineering student: Annalise Xuereb



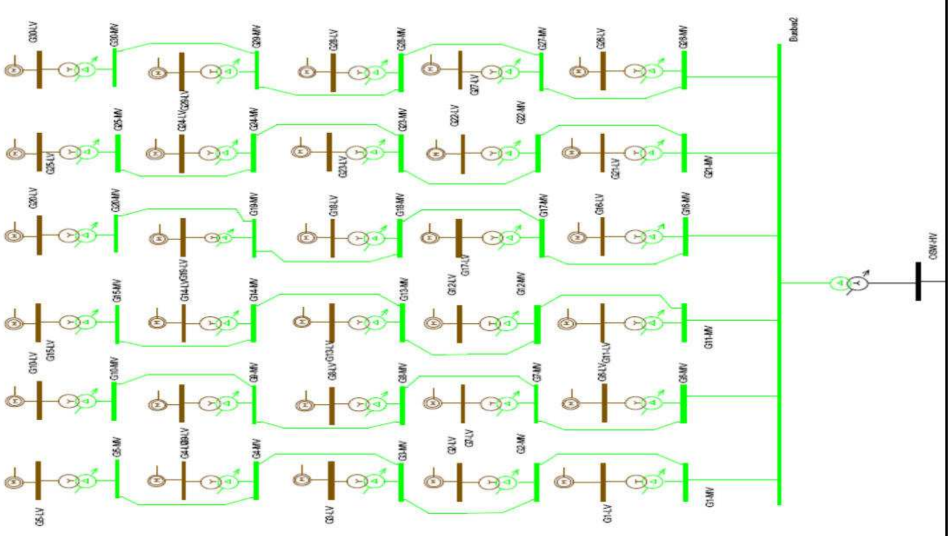
Maltese Power System Network in 2011



Model of Interconnector and Wind Farm Connection Point



Model of 100MW DFIG Wind Farm



Parameters for pre-Fault scenario

- *On average the summer load in Malta increases to about 452.2MW and 140MVAr while in winter especially during the night it can go as low as 78.93MW and 8.131MVAr [www.enemalta.com.mt].*
- Faults shall look at the case when the power systems operates at:
  - Maximum Load Demand(≈ 450MW) which occurs in summer and
  - Minimum Load Demand(≈ 80MW) which occurs in winter
- Lead/Lagging Power Factor of Power Generation from Wind Farm
- Wind Farm generating 100% or 50% of rating (100MW)
- Interconnector supplying 100%, 50% or 0% of rating (200MW)

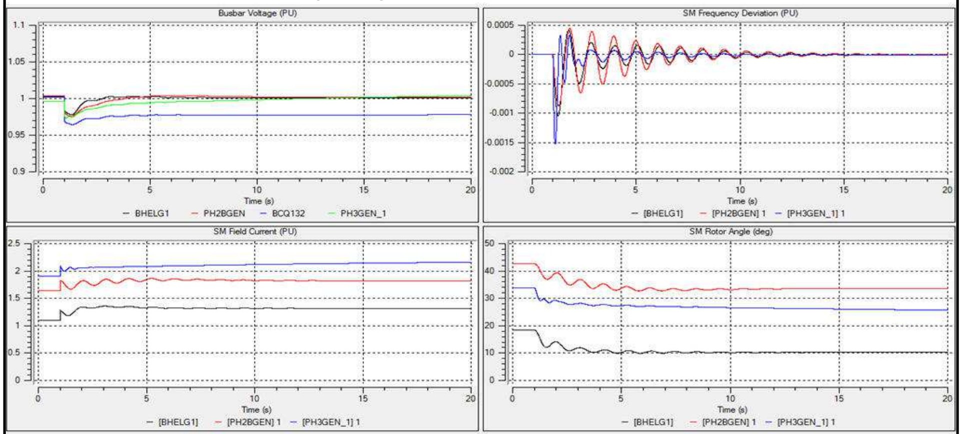
Power System Fault Analysis

In the study, Load Flow and Transient Analysis were applied to the following cases

- Disconnection of Malta-Italy interconnector
- Disconnection of the wind farm
  - when the local network is connected to mainland Europe
  - when connected to an isolated network (not connected to mainland Europe)
- Interruptions on local network were considered to test whether the wind farm can withstand such disturbances.
  - three phase fault on 132kV
  - disconnection of largest generation block

Loss of Wind Farm with Interconnector Operational

- Worst Case maximum demand (Summer)
  - WF generating 100MW at 0.9 lagging power factor
  - Interconnector importing 200MW in Summer



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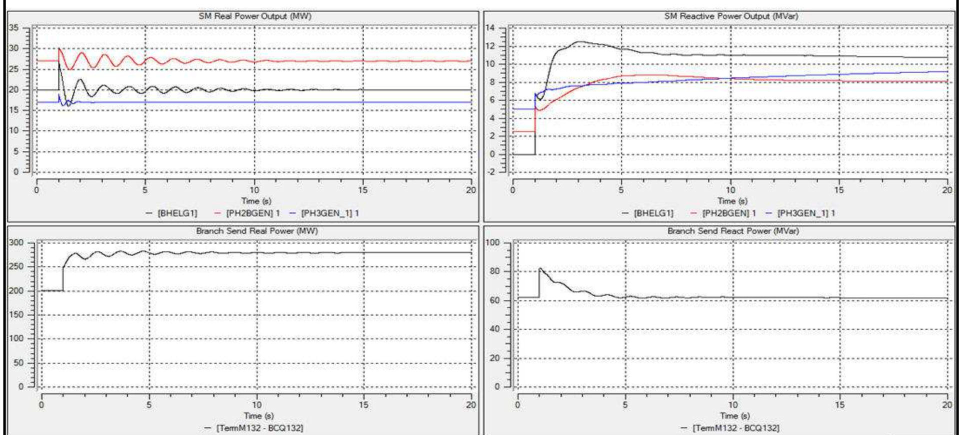
Loss of Wind Farm with Interconnector Operational

Results in large frequency fluctuations, however system recovers (Simulations showed that system remains stable even when Malta exports energy to Italy via Interconnector)



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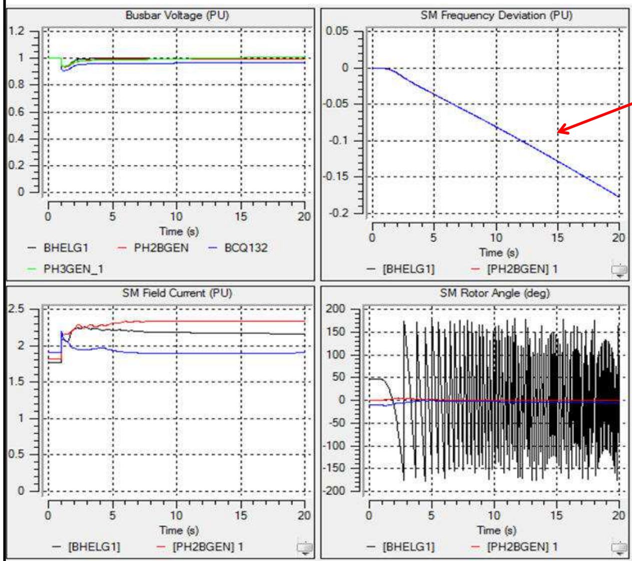
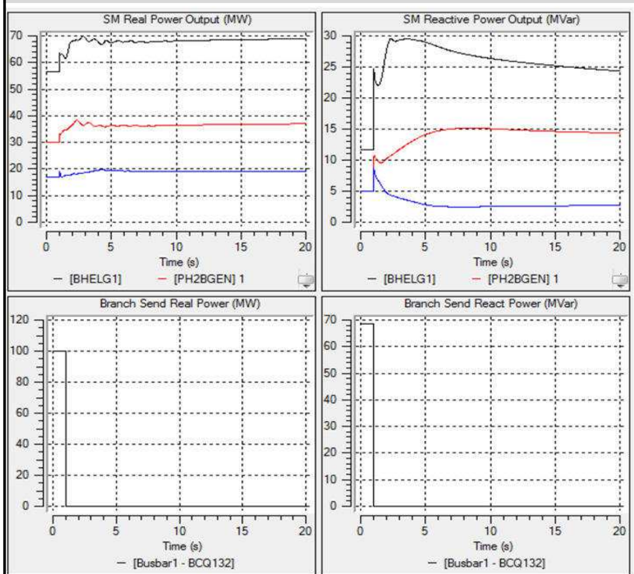
Loss of wind farm for isolated network



The Power System Frequency deviation is seen to increase negatively, thus the system frequency is slowly going down towards zero – UNSTABLE SYSTEM

Loss of wind farm for isolated network



The ability of the system to survive the loss of the WF would depend on the type and amount of spinning reserve, and the speed and the amount of load shed by the load shedding system.

Conclusions on Grid Stability with Wind Farm

- The introduction of a 100MW Wind Farm will not result in a stable network unless the connection to Sicily is operational. It was shown that the grid always managed to recover with the proposed interconnector in the network.
- The maximum summer load scenario without connection to the European grid resulted in power system instability when the wind farm is disconnected. (The sudden loss of the wind farm will eventually lead the whole system to a run-away scenario for an isolated network.)
- Simulations of three phase faults on the 132kV system and the disconnection of the largest local generation block showed that the power system managed to recover due to the fixed connection to Italy.

Wind Turbines for the Maltese Islands

Guidelines: Micro Wind Turbines

- Approved planning guidance for micro wind turbines, with an energy generating capacity of up to 20kW. Intended to promote renewable energy and cleaner resources of energy production (MEPA)
- Main issues for wind turbines: visual impact, noise, vibrations and potential effects on local ecology; Cumulative impact of multiple turbine installations, especially in urban areas. Potential impact that the turbines may have on the surrounding environment as well as other possible causes of nuisance to surrounding receptors.
- Guidelines favour installation of micro wind turbines in industrial areas, on the roofs of large buildings or within the curtilage of large buildings surrounded by large grounds situated in ODZ areas (hospitals, schools and other infrastructural facilities).
- Guidance on the potentially acceptable locations, size, efficiency and feasibility aspects. Due to the lack of information, the policy adopts a precautionary approach in urban areas due to lack of information on potential amenity impacts such as visual, noise and vibrations.

Guidelines: Micro Wind Turbines

- MEPA proposed partnership with public agencies, research institutions and NGOs to fund and carry out research to assess the potential impacts – particularly visual, noise and vibrations – of this infrastructure on residential buildings and townscapes.
- Results of these studies are envisaged to be a determining factor in any possible wider dissemination of micro wind technology in urban areas.
- The guidance calls for the need of a sensitive siting as a key element in reducing the visual impact, improve the general perception related to this technology and make them more acceptable to the public.
- Turbines are ideally located high up to take advantage of the prevailing winds; the policy proposes maximum overall height limitations for turbines as a mitigation measure against visual impact; tower mounted turbines not recommended within the grounds of historic buildings because of their conservation value.
- Larger wind turbines assessed within government's Proposal for an Energy Policy of 2009, other supporting documents published by the Malta Resources Authority (MRA), and all relevant studies necessary to inform decisions on any future applications for such development. (outside the scope of the Micro Turbine guidance).

Wind Energy in Malta

- Planning Guidance for Micro-Wind Turbines
- Studies for the impact of off-shore / on-shore wind farms.
- Concerns regarding the Feasibility in the Maltese Islands.
- Current trend of increased promotion of PV Farms to reach 2020 targets.

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