436-466 Renewable Energy

Wind Energy Assignment

Connecting your Wind Generator to the Grid

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Introduction

You live on a farm on the edge of the electricity distribution grid. You think it might be a good idea to buy a small wind generator and sell the excess electricity to one of the electricity retailers. You are aware that grid-feed inverters are readily available off-the-shelf. What hoops do you have to jump through? Do you need a licence? What price would someone pay for the electricity? Is there any relevant legislation?

At present in Australia, there are no known cases[1] of residential grid-connected wind generators (known as small wind grid-connection). This is opposed to the US and other parts of the world where the practice is far more established (see 'Appendix A'). The lack of present cases may be due to a number of reasons, including the relative slow uptake of renewable energy in Australia and the technical and economic implications and non-technical issues associated with grid-connected wind. However, the focus here is on the non-technical aspects of getting connected, which is currently possible but not as straightforward as may initially appear.

Grid- Interactive systems

Domestic grid-connected or *grid-interactive* (GI) systems are widely installed in Australia and internationally. These systems basically involve 3 connected components:

- *Energy source* - (diesel, solar photovoltaic (PV), micro-hydro, fuel cells or wind) or any combination of these – termed a *hybrid* system
- *Grid-interactive (GI) inverter* - converts direct current (DC) electricity into conventional 240V alternating current (AC) electricity
- *Meter* – indicates amount of outgoing and ingoing electricity (kWh) to/from the grid.

Figure 1 shows a typical grid-connected *renewable,* energy system. The renewable energy source produces DC electricity, which is converted into 240V AC by the GI-inverter. This AC electricity is used by the home appliances and equipment (*load* or demand). If there is surplus electricity being generated, the inverter will feed it into the main grid. Conversely, if the load is greater than what is being supplied by the energy source, the grid automatically supplies the house, via the

[1] at time of writing, one known case at Ballarat Grammar School (1kW system) is to proceed

inverter.[2] Various types of metering arrangements are available, measuring various quantities, as we will see later (see 'Metering').

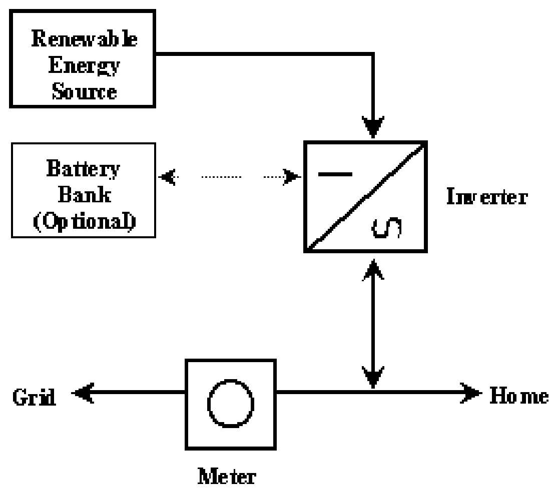

Figure 1. Typical grid-connected renewable energy system[3]

In Australia at this stage, the only renewable energy sources used in domestic-grid connected systems are solar PV cells. This may be due to the geographically nation-wide availability of solar energy as opposed to other renewable sources (ie. wind) and also the recent Australian Government Rebate for installation of solar PV systems, for both grid-connected and stand-alone systems (*Photovoltaic Rebate Program,* PVRP).[4]

Wind turbine system-sizing and location requirements

Wind-generator sizing requirements depend on the wind-regime (average wind-speed) of your location and the energy demand you expect to meet with your wind-generator. An average home uses around 20 kWh/day and the farm could use 100kWh/day. General figures indicate that a *mid-range* single wind-turbine would be suitable, rated at power output between 1kW to 5kW but even up to15kW.[5] A turbine of this size could have a rotor diameter 2m to 7m.[6]

The performance of wind turbines is affected by nearby obstacles that can create performance-restricting turbulence. To avoid this turbulence from trees and other obstacles on the ground, the height of the tower on which the turbine is placed would be between 19m to 26m. Wind velocity and wind turbine performance increases with altitude (increase efficiency by 20% every 10m), therefore your system design will require a certain tower height.

[2] Battery storage, as shown in the diagram, can be included to supply the home at times when renewable energy is insufficient to meet load. This is generally unnecessary as grid electricity can be used at these times. The battery bank can be charged by excess renewable energy and/or grid electricity. It provides an uninterruptible power supply;' *Grid-Connected Renewable Energy Systems'* Fact Sheet, Western Power

[3] *'Grid-Connected Renewable Energy Systems'* Fact Sheet, Western Power

[4] see AGO website http://www.greenhouse.gov.au

[5] as opposed to small size <1kW and large size>10kW; Alan Barlee, Installer - Solar Rays, Shepparton

[6] *Wind Generator Buyers Guide, ReNew,* Issue 63, April-June 1998

A general rule of thumb is that the tower should be placed 20 heights of the nearby upwind or downwind obstacle, away from the obstacle.[7] Space surrounding the tower is also required for access in erection and maintenance. Hence, potential sites would be restricted to properties of 1 acre or more.[8]

Non-technical issues

Regardless of technical and economic issues, there are a number of non-technical issues to be dealt with before you can produce grid-connected electricity. It must be noted, that at this stage in Australia, with the rapid developments in grid-interaction, these issues are rapidly changing and can be expected to change for some time (see 'Future of small wind grid-connection'). At this stage, these issues have only applied to solar PV grid-connection, but can equally apply to wind or any other renewable grid-connection. Issues currently involve system installation, inverter requirements and issues arising with your electricity retailer such as metering, billing, paperwork, and insurance.

Installation –Local Council Approval

Both the law and your retailer will require the wind-turbine installation to comply with local council's planning and building codes, as well as to manufacturer's recommendations.

A wind turbine would probably be classed as a 'Section 2' item,[9] and would require a *Planning Permit*, regardless of its location. This would involve a site-analysis (aerial photos, GIS information etc.) on surrounding area, and wind-turbine associated information for a 'nuisance' assessment. There would also need to be considerations made for aircraft.

Issues regarding wind-turbines of all sizes involve resident complaints regarding; visual aspects, noise, shadow flicker, geological considerations and bird deaths. These issues would all need to be addressed.

However due to the location requirements of wind turbines for performance reasons, likely locations would be limited to non-urban areas where these complaints would be minimal, such rural areas (ie. a farm as in the context of this assignment), large suburban properties, parks, schools and industrial areas.[10] Although developing on building rooftops may be a possibility.

Noise levels from wind turbines are dependent on wind speed, tower-height and the time of day (acceptable levels decrease at night). Council restrictions limit continuous noise levels to 60dB after 10pm. A typical residential wind system makes less noise than the average washing machine,[11] which is not in excess of 60dB, or likely to raise complaints (depending on the proximity of residents). Wind turbines do not interfere with TV, radio or mobile phone reception.[12]

A *building permit* should be easily obtainable as the manufacturer and owner would ensure that the tower structure is adequate.

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[7] Alan Barlee, Solar Rays
[8] *'What do I need to know to purchase a residential wind turbine,'* AWEA website
[9] Moreland Council planner
[10] 'There are no know cases for domestic wind turbines in ANY Australian council at this stage' – ICLEI. As we know many remote systems are present, rural locations would definitely be allowed.
[11] *'What do I need to know to purchase a residential wind turbine'* AWEA website
[12] '*What do I need to know to purchase a residential wind turbine,'* AWEA website

In all, if considering installing a wind turbine, council approval should be possible.

Installation – Electrical

The retailer will also ensure that electrical cabling and connection is carried out by a registered electrical contractor[13] and is in accordance with the relevant Australian Standard -Wiring Rules (AS3000). The installation may also be required to be approved by a licensed electrical inspector.

Inverter requirements

Currently, the electricity retailer determines the viability of the inverter that can be used. However, it seems all retailers require inverters that have been tested against the *ESAA 'Australian Guidelines for Grid Connection of Energy Systems Via Inverters'*.[14] These have been carried out by mainly by the University of NSW who issue test reports signifying that they have been tested (see Appendix B for list of approved inverters).

However, an Australian Standard is currently being drafted (based on these Guidelines) so that inverters must be tested against a set of approved tests by an approved authority. The Department of Fair Trading in NSW will oversee the process and once an inverter has been granted a certificate by the DFT, that approval will be recognised in other states.[15] A list of approved inverters will be collated and published on the SEIA website, and retailers will only accept inverters with a certificate. This will be a change from a permission-based system to a national standards based system.

The inverter is essentially the 'heart and soul' of a grid-connect system. It makes the connection from the resident's energy source, to the grid used by thousands of residents. The two main requirements of a satisfactory GI-inverter are that it is safe and that it provides the correct power quality for the grid.

Safety involves effective mechanisms to prevent what is known as 'islanding'. This is where a small part of the distribution network becomes isolated from the rest of the grid (eg. from a falling tree breaking wires), but remains 'live' due to an embedded generator somewhere within it. This renders line workers and the public at risk if they do not realise the grid is still active. 'Anti-islanding' devices incorporated in inverters recognise when the grid goes down, and within a second, isolate grid-supply.

The other main inverter requirement is to ensure that electricity from your system is synchronised and matches the grid power in terms of voltage, current, frequency and amplitude.

An extra complication occurs in the grid-connection of wind turbines compared with solar PV systems, in that the power output of a wind turbine is not as predictable as solar PV and while voltage may be constant, current will vary. This requires an added component installation to add capacitance and account for this varying current.

[13] usually accredited SEIA (Sustainable Energy Industry Association) installers – list available from SEAV (Sustainable Energy Association, Victoria)

[14] ESAA (Electricity Supply Association of Australia) - see ESAA Guidelines at: http://ee.unsw.edu.au/~std_mon/html_pages/inverter_guidelines.html

[15] *'Grid Connected Inverters'* – SEIA website

Retailer specific issues

All electricity retailers have their own requirements when it comes to metering, billing and paperwork (contracts and agreements) and a slightly dated summary is given in Appendix C. Due to the fledgling nature of the concept, requirements are rapidly changing, especially due to great difficulties and subsequent negotiation between motivated residents and retailers (including civil disobedience by residents[16]) to achieve the 'best' system for both parties.

Generally, there are two methods used to measure and bill the electricity consumed and produced by the grid-connected resident, *net metering*, and *dual metering:*

- *Net metering* allows residents to offset the electricity they deliver to the grid during some portion of the billing period against electricity taken from the grid during some other portion of the billing period. Residents pay only for the net electricity consumed during the billing period (net electricity delivered to the grid is usually granted to the retailer, but is sometimes paid for). Effectively, in times of excess renewable production, electricity is stored in the grid (as opposed to batteries) and this electricity is retrieved in times of insufficient renewable production.
- *Dual metering* involves measuring both the electricity going into and out of the grid, such that different rates can be charged for these amounts. Electricity is still stored in the grid in times of excess production, but is 'bought back' by the retailer at a rate less than the retail rate the resident imports at.

Metering

Various metering arrangements are possible as shown in Appendix D,[17] which measure different quantities. Retailers are requiring different arrangements depending on their desired paying arrangements and issues such as GST and generation of *Renewable Energy Credits* (REC's) (see 'Future of small wind grid-connection').

Schemes 1 and 2 involve net metering where only the net consumption or generation (ie. net import or export) is measured. Your existing rotating disk meter should run in both directions hence producing this net import/export quantity. As the wind-turbine's production increases, the meter will spin more slowly (still net import), until electricity generation exactly balances the load and the meter stands still. If generation increases relative to use, the meter spins backwards (net export). However, as these meters were probably not designed to do this, some may add up exported flow as imported flow. Hence, some retailers will require installation of new bi-directional meters, designed to run backwards and produce a net quantity.

Dual metering is performed using the 'a' and 'b' variations of schemes 1 and 2. The 'a' variations involve replacing the net-meter with a single electronic meter that records both the gross import and gross export of electricity by the resident. The 'b' variations involve two separate rotating meters to measure gross import and gross export separately. However, net metering can also be achieved with these arrangements by subtracting gross export from gross import.

Regardless of retailer requirements, for your own monitoring and load calculations you may wish to (at a cost of around $80) install a meter to measure gross generation

[16] *'Power Company Woes,'* Letters; *ReNew* Issue 74

[17] ARGON correspondence, Dave Keenan

of your wind turbine (schemes 2, 2a, 2b). This quantity is also required for the creation of RECs, for systems installed prior to April 1, 2001. As apparently no wind systems were in place prior to this date this is not an issue, as systems installed after this date will have REC's deemed by the size and location of the system.

Another possibility involves scheme 3, where gross consumption (including imported and self-generated electricity) and gross generation are measured separately. Again, different rates can be charged for these quantities.

Current metering requirements of some retailers are detailed in Appendix C. Depending on the scheme required, in some cases you will be required to replace meters at your own cost, or by paying an installation fee (both in order of a few hundred dollars). Less likely, meters may be replaced at the retailer's expense. In some cases (eg. Western Power in Western Australia) you can choose if you wish to export or not by weighing up the likelihood of export, against the cost of a gross export meter ($199).

Billing

Billing requirements, going hand in hand with metering, vary with the retailer, as detailed in Appendix C. The most popular among residents is *net billing*, using net metering arrangements. Wind is an intermittent resource, and customers may not be using power as is being generated. Net metering allows customers to receive the full value of all the electricity produced, without expensive battery storage. It reduces installation costs by eliminating the installation of a second meter (if the existing meter is adequate), and provides a simple and easily administered billing mechanism, with only one measurement required. The length of the billing period is important in that it should be long enough to account for seasonal variations (most retailers bill quarterly, however a yearly bill may be more beneficial). Most retailers using net billing give no reimbursement or credit for net export, such as Citipower and Powercor in Victoria.

An important point is that retailers lose revenue when customers self-generate. The electricity produced by the turbine and used immediately by the load is revenue lost for the retailer, who would normally have provided this electricity at a retail rate to the customer. This is regardless of metering arrangements. Rather than also allowing the excess energy produced by the customer (gross export) to offset electricity normally purchased at the retail price, the retailer 'buys back' this exported electricity at a rate less than what customers pay for gross import at retail rates. This is achieved using the *dual metering* arrangements. Buyback rates range from 7-10c/kWh compared with retail prices around 12c/kWh.

Some retailers offer buyback rates equal to retail rates, which is effectively the same as net metering. However, the GST does not allow this, as GST is required to be collected from the customer by the retailer on the on the <u>net import</u> quantity, whilst GST is not paid to the resident on the electricity exported, to forgo ABN creation and related issues. To further complicate the issue, Western Power (with buyback rates equal to purchase rates minus GST) requires GST to be collected on the <u>gross import</u>. This is not an equitable system, as those customers with net-metering arrangements will only pay GST on <u>net import</u>. However Western Power customers have an advantage over usual net-billing customers in that they may be paid for net export (but the likelihood of net export remains to be seen). Also some retailers, such as Western Power, offer different rates for different time periods.

Another complication involves those grid-connected customers opting to buy '*Green Power'*. This is where customers pay an extra 2-4c/kWh premium to guarantee that their electricity comes from renewable energy sources. True net billing would not occur unless grid-connected consumers were paid the same premium for their exported electricity. One retailer, Energy Australia (NSW) is indeed paying the equivalent rate, whereas others such as Western Power do not allow grid-connected customers to register for their Green Power program.

The retailer Energex currently uses a third billing arrangement, where scheme 3 is used (Appendix D). A much higher rate (28c/kWh) than supply rate is paid for gross generation, whilst all electricity consumed (including that from your own generation) is metered and paid at supply rate as usual. However, this gross payment is capped at 1000kWh per year (maximum of $280 off your regular yearly bill) and this metering arrangement could allow the future possibility of a lower rate paid for generation than supply.

There remains much confusion and conflict regarding metering and billing arrangements. In the future we may eventually see standard metering and wiring arrangements as part of an Australian Standard (as with inverters from ESAA Guidelines). This will hopefully require the 'best' metering and subsequent billing arrangement for both resident and retailer.

Paperwork

Apart from requiring accreditation documentation for installation, planning permits (meeting local and state government building and planning codes) and inverter compliance certificates, the retailer may not require much paperwork of its own. This of course varies with the retailer and can be dependent on system size (some require no paperwork for systems under 3kW, see Appendix C).

Some retailers may require an *application form* (see Appendix E for Powercor example), which will need to be approved by the retailer before connection. This may include a diagram of electrical wiring changes proposed by your electrical contractor. Retailers such as Western Power may also require an application to be approved by the relevant government department.

Some state legislation, such as in Queensland requires anyone intending to connect to the grid to obtain prior permission from the network owner (which is supposedly different from the retailer, see later discussion on *contestability*). This would involve a *network connection agreement,* which is the other usual type of documentation involved. If required, this document may be up to 10 pages in length and is generally intended to assure the company that your system is safe, that you understand how to use your system and that you won't modify it without informing them.[18] There may be a separate *retail agreement* required (if the retailer is separate from the distributor) which would outline billing arrangements, or possibly a separate *contract* for the same purpose.

As with other aspects of grid-connection, paperwork requirements are diverse with varying state legislation and many retailers' policies still under development. However this is rapidly changing and is far more advanced following initial

[18] '*Awake, grid-connected dreamer's,* ReNew Issue 75, April-June 2001, pp 38

negotiations surrounding problem areas in these agreements, by motivated PV grid-connect pioneers.[19]

Insurance

Retailers may argue that GI system owners create potential liabilities for the retailer (specifically the case of 'islanding) and may require or encourage them to take out public liability insurance. One NSW retailer had such a requirement where the customer was required to *indemnify* the retailer for this situation. However the high premium that was required to be maintained made grid-connection not economically feasible. With the introduction of Australian Standards for grid-connection, such liability insurance should not be required by the customer and providing installation, generation and the inverter meet the standards, retailers will be satisfied the system is safe. The liability onus will then be on the designer/installer.

Nevertheless, it is in your own interests to insure your wind generation equipment against damage to the equipment itself. It seems the most cost-effective way to insure your wind-system would be under an existing homeowner's insurance policy on your house. One 'expert' in the US advises you to call your system a 'windmill and tower' and insure its as an 'appurtenant structure'.[20] This is due to the familiarity of this term and that insurance of appurtenant structures covers for the installed cost. This is to avoid insuring as a 'wind generator' or 'electrical generation equipment', which are less familiar terms, inducing greater perception of risks and increased premiums. Insurance should cover damage from 'acts of god', fire, theft or vandalism. Most wind generators and towers should be able to withstand wind speeds greater than 170km/h, but cyclones and hurricanes can wreak havoc on them – not necessarily from the wind itself, but from objects blown into the tower. Another 'act of god' to be concerned with is lightning strikes, and appropriate protection measures in the eyes of the insurance company should be taken.

Fees

Interconnection costs the retailer and usually these interconnection costs will be passed on to the customer as fees. Of course, these will vary considerably with the retailer, but will generally come in the way of project fees, assessment and administration fees and meter fees. Meter fees will vary from nothing if your existing meter is adequate, to many hundreds of dollars if they require installation of new bi-directional, gross generation or import/export meters.

Standard 'Service to Property' charges will still apply with each bill, but renewable energy advocates will argue the bottom-line is that this is still much cheaper than battery storage.

Barriers for small-wind grid-connection

As successful wind generation requires a good wind regime, it is not applicable in all areas (as opposed to solar energy). Usually such a regime does not occur near grid and built-up-areas, but in remote areas, hence we see success in small wind as an economically feasible Remote Area Power Supply (RAPS) source.

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[19] *'Power Company Woes,'* Letters; *ReNew* Issue 74
[20] Sagrillo, Mick; *Insuring your Wind System,* AWEA website

The major barrier for the viability of all grid-connected systems is the economics. A domestic grid-connected renewable energy system can cost from $5000 to $50000.[21] The initial cost of a grid-connected wind system would involve (with some very rough cost estimates);

- Data collection (very expensive and time consuming, however data is readily available in some areas)
- Wind turbine cost: $A1000 – $A25 000
- Inverter cost: $A6000 for 3kW, plus additional capacitance component: $A1000
- Installation costs
- Insurance
- Fees (interconnection and metering) and standard charges

Depending on the performance of your wind turbine, the load of your home and proportion of this load you chose to meet with self-generation, your bill could be lowered by 50-90%.[22] You would not expect to be net-exporting electricity over a usual billing period. Due to these savings, a payback period on the initial investment is estimated to be between 6-15 years (in the US).[23] Here, SEA Victoria has estimated a payback period of 30 years (for solar PV, including government rebate). Considering current buyback rates and lack of net metering, other reasonable estimates would suggest that you would never recover your costs.

Hence it is the 'feel-good' of sourcing your electricity from a renewable source as opposed to fossil fuels, whilst avoiding energy storage (batteries) and load management (both of which could be considered the most difficult and expensive aspects of renewable energy generation) that is driving grid-connection.

Against initial perceptions, grid-connected self-generation is not an independent source of power, because if the grid does go down, the anti-islanding mechanisms mean your inverter must as well. Back-up systems can be incorporated with another inverter and batteries, but this is costly and one of the advantages of grid-connection is the avoidance of expensive battery storage.

There is currently an inequitable provision of grid-connection services across the country, with a variety of approaches taken by the different retailers as shown in Appendix C. There is neither an administrative infrastructure for trade of electricity from residents to the retailers on the grid. This means grid-connection access is restricted and there lacks a competitive market to drive the implementation of the best practice of net metering.

Future of small wind grid-connection

With public concern rapidly rising over greenhouse gas emissions from conventional fossil-fueled electricity, there will be an increasingly greater impetus for electricity to be sourced from renewables, including self-generation. This can be inferred from the

[21] ' *Grid-Connected Renewable Energy Systems'* Fact Sheet, Western Power

[22] *'What do I need to know to purchase a residential wind turbine,* AWEA website

[23] *'What do I need to know to purchase a residential wind turbine,* AWEA website

exponential developments in renewable grid-connection in Australia over the past year.

Developments can be enhanced by government intervention through regulation and incentives such as the Photovoltaic Rebate Program (PVRP) that has seen over 500 approved grid-connected PV applications since January 2000. Similar incentives for small wind investment would see to increase its incidence.

In the future we may see a growing competitive market for self-generated renewable energy by the creation and trading of Renewable Energy Certificates (RECs). These are the form of 'currency' created by the *Renewable Energy (Electricity) Act 2001* and are used to demonstrate compliance with the requirements of the Government's *Mandatory Renewable Energy Target*.[24] Electricity retailers will have to meet increasing contributions from renewable sources and will require a certain number of RECs to prove this contribution. One megawatt hour of renewable electricity generation from a new source is equal to one REC. Self-generated wind electricity is eligible to create RECs and since they can be traded through a separate market that of physical electricity, they may generate some value down the track. However this potential value remains to be seen.

Currently some grid-connect agreements automatically assign RECs created by the resident to the retailer (bodies such as the ACCC may be able to prevent this in the future). Alternatively, if retailers are not meeting their renewable contribution, some may purchase them (certain retailers are already purchasing from residents at $25 per REC).

Contestability (choose your own electricity retailer – such that your network owner may be different to your retailer), which comes into full nationwide effect in January 2002, will also affect the trade in RECs where competition for sale of exported power (and possibly RECs) from residents should rise.

Other possibilities are REC purchase by a broker, or other third parties such as the grid-connect installer or environmentally conscious organisations, who could deal them in bulk on the open market. These organisations or the GI owner may also accumulate and 'sit on' them to create further sourcing requirements of renewable electricity. Future REC values will depend on Australia's stage in meeting the mandatory target and developments in all types of renewable energy production. If they do generate value, this will create an incentive for investments in grid-connected wind.

The widespread enabling of grid-connection in Australia can only be achieved if the barriers outlined in the previous section are overcome. A nationally consistent, standards based grid-connection procedure would allow more equal access to connection, regardless of retailer. Australian standards are currently being drafted for the technical aspects of connection (inverter, metering, wiring). This should allow more straightforward grid-connection and minimise costs for both parties. Once the standards are met, you simply inform the network owner and retailer and then connect, with no permission administration required. Also, by addressing legitimate network safety and power quality concerns, liability on residents is eliminated. Uniform technical standards may also allow reduced costs of inverters and renewable generation equipment through increased 'economies of production.'

[24] 'By 2010, 2% of Australia's electricity must be produced from renewable sources (9500GWh)'; AGO website www.greenhouse.gov.au

The introduction of an administrative infrastructure for trade of electricity from resident to retailer, such as a representative ombudsman, would enable a competitive market to drive the implementation of best practices regarding billing and agreements. Currently, it is the highly motivated GI ‘pioneers’ who are pushing the retailers and relevant government and industry bodies into overcoming ignorance and solving the ‘teething problems.’

Net metering needs to be present to encourage investment in GI renewable energy systems. This is especially in the case of wind, as opposed to solar, where wind generation tends to coincide less with electricity usage. In some states of the US the law requires net metering. Reduction of fees is also required to allow a more economically feasible system.

Retailers would have a conflict of interest when it comes to renewable self-generation by residents. It is both a nuisance and an economic threat, just like other demand reduction and energy efficiency measures adopted by residents. It costs them money (however interconnection costs are usually passed on to residents) and residents are using the network’s facilities to ‘store’ their electricity. The revenue losses associated with self-generation don’t seem significant in Australia yet, but if everyone self-generated, retailers would be losing out. To keep revenue losses to acceptable levels in the US, retailers impose constraints on net metering such as placing limits on; the size of systems, eligibility of certain technologies, the number of self-generating customers or their overall eligible self-generating capacity. Rates could be increased, or there is the possibility of restructuring rates from usage based ($/kWh) to fixed charges, providing more stable revenue and reducing revenue losses caused by demand reduction.[25] Implementation of such actions in Australia would all serve to discourage self-generation, but at this stage we are still on the upward curve.

Nonetheless, retailers like the promotional and image value of partaking in such environmentally friendly schemes. Furthermore, with full contestability, competition will encourage retailers to try and attract environmentally concerned customers by allowing straightforward access to schemes such as grid-connection. This is important in the case of wind grid-connection, where currently not all retailers have networks in good wind-regimes. Contestability will give them the chance to purchase wind-energy and hence attract renewable energy advocates.

Hence, despite possible conflicts of interest, retailers are positive towards grid-connection and are progressing along the learning curve.

Conclusion

Depending on your location, producing your own environmentally benign electricity through grid-connected wind is definitely possible, even if not economically advantageous. Currently there are a number of issues that are retarding the incidence of grid-connection, which includes non-technical aspects. However as the industry stabilises and appropriate standards are introduced, and if the rapid rate of development and overcoming of ‘teething problems’ continues, we will definitely see more widespread adoption of all types of grid-connection, including small wind.

[25] Starrs, T J, *Net Metering and Interconnection, Interconnection Barriers: Solutions for the Million Solar Roofs Initiative*

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- *'Barriers to Grid Connection for household photovoltaic systems'*, AGO, 2001
- *'Customer Guidelines for Grid Connection of Inverter Power Sources up to 20kW*'; Powercor
- *'Generate Your Own Power'*, Citipower website
- *' Grid-Connected Renewable Energy Systems'* Fact Sheet, Western Power
- *'Grid Connected Inverters'* – Sustainable Energy Industry Association (SEIA) website; http://www.seia.com.au
- *ReNew Issues 63, 74, 75*
- *'Renewable Energy Certificates'*, Fact Sheet, Office of the Renewable Energy Regulator
- Sagrillo, Mick; *'Insuring your Wind System'*, AWEA website
- Starrs, T J, *Net Metering and Interconnection, Interconnection Barriers: Solutions for the Million Solar Roofs Initiative* http://www.ttcorp.com/upvg/interconn/tab%202/
- *'What do I need to know to purchase a residential wind turbine,'* American Wind Energy Association (AWEA) website http://www.awea.org
- *Western Power's 'Residential Renewable Energy Buyback Scheme'*

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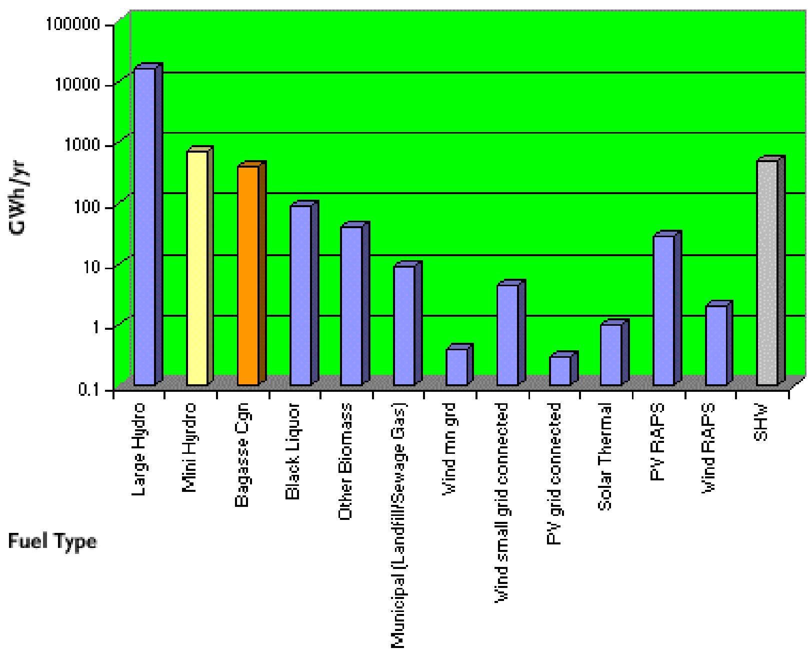
- Australian Wind Energy Assoication (AWEA)
- The Australian Greenhouse Office (AGO)
- Citipower
- International Cities for Climate Protection? (ICLEI)
- Moreland Council, Planning
- SEIA
- Sustainable Energy Association of Victoria (SEAV)
- Sustainable Energy Development Authority (SEDA) NSW
- Western Power

APPENDICES

APPENDIX A



World Renewable Energy Capacity 1997

APPENDIX C - RETAILER SUMMARY

Retailer	Metering requirement	Protection requirements	Billing option	Customer contract	Contact	Website
CitiPower	Current meter is assessed and replaced if it is not suitable.	ESAA compliant inverters	Net-metering	Open ended contract.	Peter Zwack (03) 9297 8682	www.citipower.com.au
TXU (formerly Eastern Energy)	A11 meter required - bi-directional meter (also does profiling) Small cost for new meter Net meters on customers side of the meter.	ESAA compliant inverters	Net-metering Measures Export is a full credit at future import. 12 -month rolling credit in place.	Standard residential - Up to 2kW Over 2kW individual cases	Adam Feldman (03) 9229 5909	www.txu.com.au
Pulse (formerly United Energy)		ESAA compliant inverters	Net-metering		Craig McMahon 9265 7881	www.pulsenet.com.au
Powercor	New meter Bi-directional meter	ESAA compliant inverters	Net-metering Quarterly billing	Powercor contract	Ross McPherson (03) 9683 4839	www.powercor.com.au
AGL	New meter required. An extra meter required	ESAA compliant inverters	Electricity purchased at 7c per kWh	Owner signs interconnection agreement.	Mark Connolly (03) 9201 7692	www.agl.com.au

Energex	?	ESAA compliant inverters	Electricity purchased at 28c per kWh	?		
Western Power	New meter Bi-directional meter Supplied by retailer	ESAA compliant inverters	Electricity purchased at same rate of incoming power, less GST (13c/kWh)	Renewable Energy Buyback Scheme		
		ESAA compliant inverters	Electricity purchased at 7c per kWh	Owner signs interconnection agreement.		

APPENDIX D

Metering classification scheme (courtesy of David Keenan, Brisbane – ARGON network)

Single meter

```
1.      .--- Inverter
Grid -O-|                      Net consumption/generation only.
        `--- Loads
```

Two meters

```
2.      .-O- Inverter          Gross generation and
Grid -O-|                      Net consumption/generation.
        `--- Loads

3.      .-O- Inverter          Gross generation and
Grid ---|
        `-O- Loads             Gross consumption.
```

Note that, with a 3-way star like this, if you measure the net energy thru any two legs you can calculate the energy in the third leg. A fact that is lost on some electricity authorities.

Then there are the "a" variations where the Net meter (which is typically your standard rotating disk meter allowed to rotate forwards and backwards), is replaced by an electronic meter that records two separate numbers for import and export.

Single meter

```
1a.     .--- Inverter
Grid -8-|                      Gross Import/Export only.
        `--- Loads
```

Two meters

```
2a.     .-O- Inverter          Gross generation and
Grid -8-|                      Gross Import/Export.
        `--- Loads
```

Then there are the "b" variations where the single smart meter is replaced by two meters in series. Import is read from one and export is read from the other. These may be two rotating-disk meters with reverse-running-stops fitted (in opposite directions) or they may be two smart meters, despite the fact that a single smart meter alone could give both numbers.

```
1b.       .--- Inverter
Grid -6-9-|                    Separate Gross Import and Export.
          `--- Loads


2b.       .-O- Inverter        Gross generation,
Grid -6-9-|                    Separate Gross Import and Export.
          `--- Loads
```

The "a" and "b" variations cannot be applied to scheme 3.

Notice that Gross-generation is not the same as Gross Export, and Gross consumption is not the same as Gross Import, although some electricity authorities seem to think they are. The difference in both cases is the energy you use yourself immediately as it is being generated. Of course Net consumption/generation is the same as Net import/export.