Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia Engineering 49 (2012) 57 – 65

Procedia Engineering

www.elsevier.com/locate/procedia

Evolving Energy-IEF International Energy Congress (IEF-IEC2012)

Prospects and problems of increasing electricity production from mid-size renewable energy generation on the South-West Interconnected System (SWIS) in WA

Delphine de Babline[a], Tania Urmee[a]* Jamie Ally[b]

[a]School of Engineering And Energy, Murdoch University
[b]General Manager, EMC limited

Elsevier use only: Revised 11th July 2012; accepted 12th July 2012

Abstract

Western Australia (WA) is truly blessed by abundant and readily available renewable energy resources. Yet most of its energy use still comes from fossil fuel energy. In the case of the South-West Interconnected System (SWIS), which is the largest grid of the state, renewable energy represented only 4 percent of the total electricity production in 2009-2010. From these two facts, this paper looked at the possible causes of such a small production of renewable energy and the future development of renewable energy technology for the SWIS in the coming decades. It was noticed that the SWIS and its economic and political structure tend to create barriers to renewable energy through strict market rules and lack of political will. This is particularly true for mid-size renewable energy (RE) facilities of less than 30MW, which cannot compete with traditional electricity production and are faced with technical issues to be integrated in the energy mix. In addition, strong lobby groups, encouraged by abundant fossil fuel reserves in WA, deepen the obstacles preventing fast development of renewable energy for the SWIS. There are many opinions and studies of various academic and industry experts that claim it is technically and practically possible to produce 100% of electricity from RE by 2050 in some parts of the world, which is also valid for the SWIS. However, with the current barriers and policies in place, it is very unlikely that the SWIS would achieve such an outcome. This paper discusses the barriers and driving factors of the RE sector and the possibility to improve RE production for the SWIS. It also discusses the role of the government in the energy market to increase RE penetration in the SWIS.

Keywords: South West Interconnected System; Renewable Energy; Policy framework

1. Introduction

The South West Interconnected System (SWIS) is an islanded network separated from the National Electricity Market (NEM) and the North West Interconnected System (NWIS). It generates most of the electricity from fossil fuels. The SWIS is the main electrical network of Western Australia and provides electricity to almost a million customers in the Perth metropolitan area and extending from Geraldton at the North of Perth, Albany at the South of Perth and stretching to Kalgoorlie-Boulder at the East of Perth[1]. In 2009, the SWIS had an installed capacity generation of 5134 MW [2]. Figure 1 presents a map of Western Australia showing the area served by the SWIS system (the region highlighted in yellow). Total installed generation capacity of this network is just over 5,134MW of which 65% are owned by the State Government generator, Verve Energy. The remaining 35% is privately owned and supplies around 840,000 retail customers[3].

* Corresponding author. Tel.: 618 9360 1316; fax: +618 9360 6346.
E-mail address: t.urmee@murdoch.edu.au

1877-7058 © 2012 The Authors. Published by Elsevier Ltd. Selection and/or peer-review under responsibility of the International Energy Foundation
doi:10.1016/j.proeng.2012.10.112

Fig. 1. Western Australia Energy Infrastructur Map with area served by the SWIS; Source:[4]

Electricity production from renewable energy (RE) for the SWIS is fairly small and not constant, and the use of coal and gas dominates the rest of the electricity generation. Figure 2 presents the different energy sources used to produce electricity on the SWIS.

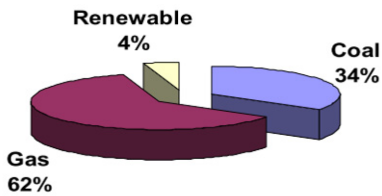

Fig. 2. Installed Capacity of the SWIS according to energy resources as of 2009; Source:

From figure 2 we can see that mainly coal and gas are used for most of the electricity generation. These resources may be plentiful at present but they are exhaustible. Moreover, they are certainly not providing the clean energy, energy price stability, and independence needed for present and future growth of WA. Therefore, in the case where fossil fuels would be running low or exhausted, it is unlikely that WA would find itself capable in dealing with its energy demands given the current nature of its energy sector. WA has been faced with the scarcity of these resources in the past, where the consequences were severe for the economy. For example, the gas crisis of 2008, where an explosion occurred at the Apache gas plant on Varanus Island, one third of the WA gas supply was cut and this forced part of the industry, including the booming mining industry, to shut down or run at low production[5, 6]. This crisis and future fossil fuels shortages emphasize the need for energy security and independence and should have acted as a warning sign of what the future may look like if no action is taken. RE can provide the supply security and independence sought by the entire world at this time of energy instability and insecurity, where energy dependence creates high risks for a country's prosperity and international relations.

This study encompasses the barriers and drivers for the development of medium scale RE facilities on the SWIS. The barriers are investigated at different levels including economic, political, social and technical factors and help identifying the factors that can bring down those barriers and enhance RE development.

2. History and Synopsis of the Current Market, Policy Settings and Framework

During the reform process in April 2006, the state's energy industry reforms reached a major milestone when the state owned vertically integrated electricity utility, Western Power Corporation, disaggregated into four entirely separate corporate business entities[4, 7].

- Western Power, responsible for the ownership and operation of the SW electricity grid (known as the SWIS – south west interconnected system) which connects generators of all types to consumers' installations.

- Horizon Power, responsible for the ownership and operation of what were previously Western Power's remote electricity supply systems (including some local generation facilities), and the retailing of electricity to customers, in most towns of the far north of the State, the Pilbara and Esperance.
- Synergy, responsible for the retailing of electricity to what were previously Western Power's customers in the SWIS.
- Verve Energy, responsible for ownership and operation of what were previously Western Power's power stations connected to the SWIS.

That disaggregation opened the electricity market to wider competition. An Independent Market Operator (IMO) was established to administer and operate a wholesale electricity market (WEM) for the SWIS, which is essential if genuine competition is to exist and grow in that system.

The electricity market reforms related to open access of electricity networks in the SWIS were expected to deliver positive outcomes for Independent Power Producers (IPPs), in particular, renewable energy power generators. During the market reform process, numerous references were made to the benefits for renewable energy but the objectives of the new legislation did not explicitly refer to renewable energy. It was assumed that opportunities for IPPs from the renewable energy sector would improve as a result of this reform process. It is certainly the case that renewable energy penetration in the SWIS has increased from below 1% to over 5% since the reforms were introduced. Despite the advantages that have accrued to the sector as a result of electricity market reforms, persistent barriers remain. It is therefore important that the process of market reform continue in order to realize the potential benefits for the renewable energy sector. The WEM is different in structure and operation to the National Electricity Market (NEM) and is considered by some proponents to be more complex. Ernst & Young (2008) noted that unfamiliarity with the WEM may create barriers to the introduction of renewable energy sources by the major Australian energy developers[8].

3. Load profile of the SWIS and the Independent Market Operator (IMO)

The load profile of the SWIS is characterized by its diurnal and seasonal variations with high load peak during summer and winter, and very low peak at night (ESAA 2009). Figure 3 represents the typical summer day on the SWIS. The peak demand increases constantly during the day until 5 to 6pm, where it reaches its maximum point. This peak demand is partly due to the use of air-conditioning during summer days. The typical winter load has a different peak demand curve, characterized by the use of heating systems in the morning from 7am to 10am and at night from 5pm to 10 pm, as it can be seen in Figure 5. In addition to the peak and off peak characteristics, the SWIS must address to base load [9].

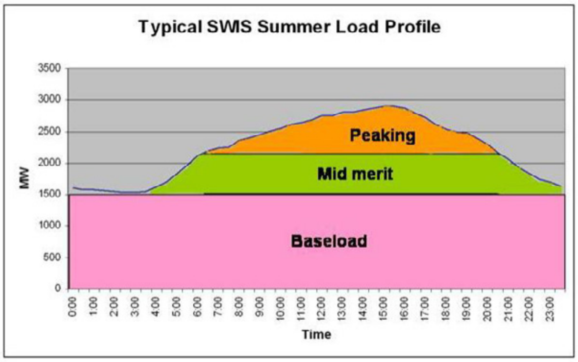

Fig. 3. Load during a summer day; Source: [9]

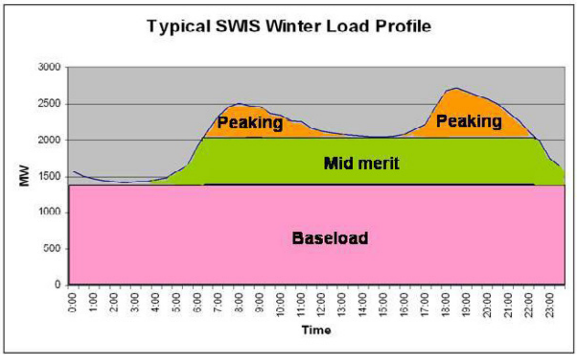

Fig. 4. Load during a winter day; Source:[9]

The SWIS has three levels of power generation plants: baseload, mid-merit load and peaking load plants to address its load demand. The baseload is mainly provided by coal plants with some additional support from gas-fired power plants [10]. These plants are economically justified by the government and the WEM by the nature of the SWIS load. According to Western Power, 25% of the power demand only exists for less than a few percent of the time, as shown in the Power load duration graph below (figure 5). Figure 5 shows that peak demand occurs for less than 5% of the time. So if the peak load were clipped off by 'shifting' some demands to off-peak periods, a significant amount of infrastructure and costs can be avoided. Due to the nature of coal generation it is not possible to vary plant power output to follow the peak demand load, whereas energy sources such as biomass, solar thermal with storage, geothermal and wave are more 'dispatchable', and can vary their output to quickly follow the demand, and complement those renewables which are naturally intermittent. This creates an opportunity to feed in RE sources at distributed locations around the grid, which will then improve the diversity, security and resilience of the supply.

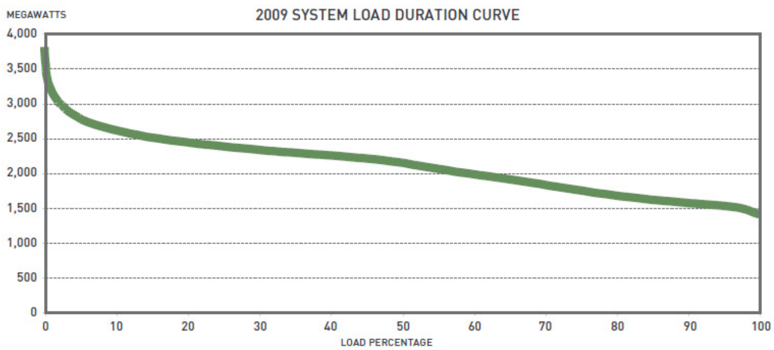

Fig. 5. System Load Duration Curve; Source: [11]

Due to the distances between the SWIS and the national grid, it is highly unlikely that the SWIS and the national grid will be connected in the foreseeable future; therefore the SWIS is treated independently from the National Electricity Market (NEM) and hence follows special regulations set by the IMO since 21st September 2006 to ensure a fair, safe and reliable electricity supply to the consumers[12, 13].

4. Renewable Energy Resources in WA and its Opportunities for SWIS

There are abundant renewable energy resources including wind, solar, wave, geothermal and Biomass in Western Australia (WA). It also has large areas of land and coastline that are suitable to capture these resources. The commercially competitive technologies are listed below:

- Wind farms in WA have some of the highest capacity factors in the world, at about 40% compared to an average of 30% in South Australia, which has the next best wind resource in Australia.
- Carnegie Wave Energy estimates that there is enough wave energy along WA's coastline between Geraldton and Bremer Bay to produce more than five times the SWIS peak electricity demand.

- Solar irradiation in WA reaches the highest levels in the world. In Australia we have twice the amount of solar irradiation as Germany and yet Germany produces about 100 times the amount of electricity from solar energy[9]. Most of WA experiences an average of between 8 and 10 hours of sunshine daily.
- It is interesting to note that under the Perth metro area there is an easily-accessible hot sedimentary basin with water temperatures estimated at up to 150 degrees Celsius at a depth of 3-4km.
- Western Australia also has the advantage of space, with vast stretches of non-agricultural land. Such land is not only useful for the installation of sustainable energy systems but, where it has been made unproductive by dry land salinity and soil erosion, could also be revitalised by a regional biomass industry, using oil mallee plantations to enrich soils.

Some renewables are commercially competitive now while others are in various stages of development. Technologies go through a cycle of development, as shown in the 'Grubb' curve below (figure 6). Generally the costs also reduce as they become more mature and with increasing mass production and economy of scale.

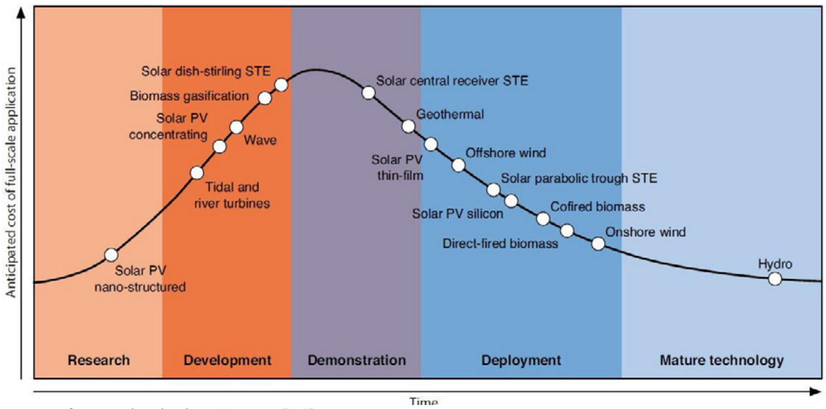

Fig. 6. Grubb curve for a range of RE technologies; Source: [14]

The table below translates the information from the Grubb curve. It indicates the assumptions of the state of maturity of several renewable technologies.

Table 1. Maturity of a Range of RE Technologies

Renewable Energy Conversion Technology	Present Status
Solar Thermal	Commercial (against peak electricity generation cost
Wind	Commercial
Biomass	Development-commercial
Solar PV distributed	Commercial against retail electricity
Geothermal –Hot Sedimentary Aquifers (HAS)	Demonstration-Commercial
Geothermal –Hot Dry Rock (HDR)	Demonstration
Wave- Carnegie CETO	Demonstration

From the table we can see that many technologies are currently commercially available and some are even already cost competitive with fossil fuel. The present retail price of the SWIS fossil-fuelled electricity supply has increased by 50% since April 2009 and is expected to continue to rise to reflect the true cost of electricity supply. This excludes any price on carbon, which will further increase the electricity generation cost from fossil-fuelled power stations. Costs of renewable electricity generation presently range from being competitive with fossil generation to higher. However, the downward cost trend for these technologies will continue over time as technology advances, and mass-production and size of power systems increases in scale (See the Grubb curve shown in Figure 6).

5. Producing and distributing electricity of the SWIS

5.1. The SWIS market rules

The production of electricity from renewable energy is small on the SWIS. There are a total of 17 renewable energy facilities connected to the grid, as listed in Table 1. Most of the facilities are landfill gas. However, wind energy represents the biggest portion of the renewable energy distribution on the network, with 79% of the total renewable energy generation generated from 5 facilities. (Clark 2011). Biomass represents 18% of this distribution with a total of 11 facilities. Hydro has a very minimal amount of this share with the one facility of 0.13MW.

Table 2. Renewable energy facilities connected to the grid

Energy Source	Capacity (MW)	Suppliers	Location	Year commissioned
Landfill gas	2.65	Landfill Gas and Power Pty Ltd	Red Hill	1993
Landfill gas	2.6	Landfill Gas and Power Pty Ltd	Canningvale	1995
Landfill gas	0.6	Landfill Gas and Power Pty Ltd	Kalamunda	1996
Sewage Gas	1.8	Water Corporation	Woodman Point	1998
Wind	21.6	Verve Energy	Albany	2001
Landfill gas	1.7	AGL Energy Services Ltd	Rockingham	2003
Landfill gas	1	AGL Energy Services Ltd	Gosneils	2003
Landfill gas	4.65	Landfill Gas and Power Pty Ltd	Tamala Park	2004
Wind	0.66	Verve Energy	Bremer Bay	2004
Landfill gas	1.1	Landfill Management Services	Noranda (Atlas)	2005
Landfill gas	3.3	Landfill Management Services	South Cardup	2005
Landfill gas	2.13	Waste Gas Resources	Henderson	2005
Wind	90	Alinta	Walkaway	2005
Wind	80	Griffin Energy	Emu Downs Wind Farm	2006
Hydro	0.13	South West Development Commission	Pemberton	2006
Organic Waste	1.29	Mount Herron Engineering	Mandurah	2007

Finally solar energy has no generating facilities on the SWIS but represents 3% of the renewable energy distribution. This is mainly due to the large number of micro solar systems, mainly in households, connected to the grid. As mention before the IMO is responsible for overseeing the energy market of the SWIS and sets its rules through the WEM. The rules are designed for generators directly connected to the SWIS regardless of their size and these rules are strict and inflexible. They represent many constraints for the energy industry but are designed to ensure the energy security of the SWIS at 99.9%. To achieve this goal, the IMO applies a scheduled generation policy, where electricity generation of the SWIS is included the Frequency Control Ancillary Services (FCAS) and other measures to ensure the energy security of supply to the grid is planned in advance. The WEM contains two main components: the trading component which is the trading between Short Term Energy Market (STEM) generators and retailers, and the Reserve Capacity Mechanism which handles the long-term planning of the electricity generation assets connected to the SWIS. To ensure the stability and security of energy supply, the IMO plans ahead the production of electricity which is achieved through the capacity credit scheme, where the IMO issues capacity credits to the generators and demand-side management operators that obligates them to have a contracted amount of generation capacity (or DSM capacity) available [10].

5.2. Renewable energy policy in Australia and WA

The WA state government's policy and planning issues have enormous implications for the viability of renewable energy installations in SWIS. According to a paper produced jointly by Sustainable Energy Association and two other consulting companies, the specific barriers that apply directly to renewable energy generation projects include[15]:

- Inconsistencies between the planning and approvals processes of different Local Government Authorities
- Lack of standards and compliance requirements
- Government reluctance to fund infrastructure
- Inconsistency of Standards and compliance requirements
- Renewable Energy Buyback Scheme not offered for Commercial sector
- Uncertainty in feed-in-tariff
- Poorly designed incentives from federal government
- Rapid changing in federal rebates and schemes

Lack of consistency in energy policy greatly reduces opportunities for renewable energy, and blocks the emergence of a strong renewable energy industry operating on the SWIS. Such weaknesses in policy tend to make renewable energy more expensive, and builds the perception that renewable energy is a dangerous investment in WA [16].

5.3. Barriers to the development of mid-size renewable energy facilities in the energy mix of the SWIS

Some claim that the introduction of the WEM in 2005 facilitated market competition and helped the boom of renewable energy on the SWIS since the implementation of the new market rules. However, weak market competition has limited the possibilities for mid-size renewable energy facilities. Mid-size renewable energy would have to face the same connections and distribution charges as large-scale facilities with high capital costs and less return on a proportional basis[17]. Developing renewable energy on the SWIS is further encumbered because the energy market at this stage is not competitive for renewable energy and enhances the price of electricity produces from renewable energy sources. There are number of technical barriers to increase the RE share in the SWIS. According to [11] the number of technical aspects to be addressed to assist an increase in RE generation are:

- The grid design and capacity needs to be upgraded to allow electricity to be distributed from various parts of the grid.
- There must be an integrated grid upgrade strategy which considers where future sources of energy and demand will be.
- The grid stability is a barrier but can be improved for renewables by forecasting the resource using meteorological data.
- A more sophisticated resource forecasting and electricity market design can accommodate higher levels of renewable energy onto the network, and a greater range of DSM options at least cost.
- Energy storage on the grid including pumped air/hydro, thermal with solar thermal plants, and EVs (V2G), are needed to complement the use of larger amounts of intermittent renewable energy such as wind and solar.

The connection of mid-scale renewable energy facilities presents a problem regarding the capacity of the SWIS to integrate various inputs that are likely to fluctuate during the day, affecting the security of supply for baseload and peak load [18]. Also renewable energy facilities are often located away from transmission and distribution lines as well as centres of consumptions. Developing such lines, often located at the extremity of the grid where the renewable energy sources are most available, are expensive, and this effect is amplified for medium size renewable energy plants[19].

6. Conclusion and Recommendation

From the above discussion, it is clear that the RE industry has little chance of growing without help from the government. Without strong and focused government policies that engage in the development and commercialization of renewable energy, the growth of the industry will most likely continue at a very slow pace. This is because funds are influenced by market forces which favour cheaper and more profitable energy sources such as fossil fuels. A number of barriers are faced by the RE industry for new generation to enter the marketplace, particularly through the current regulatory system that has been based on the philosophy of large scale centralised generation.The complexity of regulation places a disproportionate regulatory burden on small scale, distributed generation, and small-scale commercial uptake of RE. These burdens can make adoption of renewable energy use, other than through the purchase of Green Power type products, uneconomic. At the same time, if the market is fairly liberal, an energy market can be developed to encourage the growth of the RE sector.

Currently, the SWIS market structure and the technical weaknesses of the SWIS greatly limit a high penetration of RE. Looking at the barriers to an increase of RE in the energy mix of the SWIS network, we can see that most of them are heavily drawn from political and economic issues. That is to say that if the technical barriers were to be solved, a strong intervention by the government through specific policies would be necessary to achieve a more liberal market that is more conducive to RE.

The current national and state policies in regards to renewable energy have had some positive outcomes on the development of RE and reduction of greenhouse gases. However, they greatly limit the full potential of the RE sector through unwanted barriers and, perversely, indirectly encouraging traditional electricity generation to keep growing instead of RE. The following is the list of recommendations to address the barriers to renewable energy uptake that have been identified in this paper:

- Carry out policy advocacy with the state Government in order to highlight the effect of barriers on renewable energy uptake in WA
- Address these issues of competition within the market place and to remove inefficiencies in the electricity market.
- Provide feedback on the design and operation of renewable energy programs to reduce policy and legislated barriers to renewable energy adoption.
- Pursue governments to improve scheme administration so the uncertainty can be reduced from perceived “policy on the run” within the market which acts as a barrier to longer term RE industry development.
- Remove systemic barriers to renewable energy adoption. This can only be achieved through collaboration amongst the relevant government entities (IMO, ERA, Western Power, the Public Utilities Office, and the relevant state government elected officials).

References

[1] Energy, Perth. (2010).*Market and Consumers*. [cited 2011 Septemver 28]; Available from: http://www.perthenergy.com.au/electricity-market-mainmenu-69/market-a-consumers-mainmenu-72.

[2] AER, -Australian Energy Regulator - (2009), *Annual publication, State of the energy market 2009*, in *Beyond the national electricity market*. Melbourne, ACCC.

[3] LGP, Landfill Gas & Power Pty Ltd -. (2012).*The South West Interconnected System (SWIS)"*. [cited 2012 September 30]; Available from: http://www.landfillgas.com.au/retail-electricity-sales/south-west-interconnected-system.html

[4] WAOE, Western Australia Office of Energy - (2011), *Annual report 2010-2011*. Office of Energy Perth.

[5] Medlen, Pamela. (2011), *Have the People of Perth forgotten the gas crisis*, in *ABC News*.

[6] Megalogenis, George and Sarah-Jane Tasker. (2008).*WA gas crisis poses threat to national economy*. [cited 2011 December 11]; Available from: http://www.perthnow.com.au/gas-crisis-threat-to-nation/story-fna7dq6e-1111116610505

[7] McHenry, M.P, (2009). *Policy options when giving negative externalities market value: Clean energy policymaking and restructuring the Western Australian energy sector.* Energy Policy. **37**(4): p. 1423-1431.

[8] Ernst & Young (2008), *20-20 vision Investment challenges and opportunities arising from Australia's 20% renewable energy target.*

[9] Waters, Jason. (2009), *Electrcity Options for the Future- where will WA's power come from*, in *Australian Engineering Week Public Forum*. 2009, Verve Energy: Perth.

[10] IMO (2006 a), *Wholesale Electricity Market Design Summary*. 2006 a, Independent Market Operator: Perth

[11] SEN. (2012).*Renewbale Energy Scenerios for Western Australia: Discussion Paper* 2012 [cited 2012 May 10].

[12] IMO (2006), *The South West Interconnected System Wholesale Electricity Market: "An Overview"*. in *Guidelines*. 2006, Indipendent Market Operator: Perth

[13] Landfill Gas & Power Pty Ltd. ". 2008. (accessed September 28, 2011). *The South West Interconnected System (SWIS)*. [cited 2011 September 11]; Available from: http://www.landfillgas.com.au/retail-electricity-sales/south-west-interconnected-system.html.

[14] ABARE (2010), *Australian Energy Resource Assessment*. Australian Bureau of Agricultural and Resource Economics Perth.

[15] WASEA, WA Sustainable Energy Association-, HAC Consulting, and Future Smart Strategies (2010), *Regulatory Barriers to Sustainable Energy in Urban context in South-West Western Australia*. Perth. p. 30.
[16] HAC Consulting, Future Smart Strategies, and *WA Sustainable Energy Association*. (2011).*Regulatory Barriers to Sustainable Energy in Unrban Contexts in South-West Western Australia.*
[17] Western, Power (2006), *Pricing Structure for the Transmissions and Distribution Network Businesses*.
[18] Wilkes, Paul (2010), *Comments on the West Autralian Strategic Energy Initiative Issues paper*, in *SEN*. 2010: Perth
[19] IMO. (2008).*Design Options for the Expanded National Renewable Energy Target Scheme*.