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Upgrading a Medium Size Enterprise Power System with Wind and Solar Sources: Design, Financial and Environmental Perspectives

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***Abstract*—Efficient generation and distribution are crucial for economic power production. In this paper we discuss the planning and design of upgrading a medium size enterprise power system by installing Distributed Energy Resources (DERs), with particular emphasis on economic viability and environmental benefits. The planning for this project considers both conventional grid and $SmartGrid$ connections. Project planning, installation challenges and governmental support of renewable energy projects in Australia are discussed. It is found that upgrading a medium size enterprise power system with DERs can yield reasonable levels of energy cost savings and greenhouse gas mitigation with both conventional grid and $SmartGrid$ connections, but that $SmartGrid$ connection can deliver better outcomes.**

***Index Terms*—medium size enterprise power systems, solar and wind energies integration with smartgrid, economic and environmental analyses of energy projects**

I. Introduction

Concerns over catastrophic climate change, increased industrialisation, CO_2 emissions and fuel price rises are creating incentives for reliable, safe and environment-friendly energy sources. To help achieve a clean and secure electric power industry, the current power grid has been modernised to accept a range of renewable energy sources [1]. These are expected to become more competitive with conventional generators. As a part of the international trend towards restructuring electricity grids, many developed countries are establishing new investment support policies. They are also developing legislation for commercializing "Green Energy". As new clean-energy markets have been emerging around the world, opportunities exist for economic development, jobs creation and energy diversification benefits [2]. Thus, there is a need to develop efficient clean-energy regulations to direct companies, so that socio-economic benefits are maximised [3]. Regulators are initiating new programs for energy efficiency, renewable energy capacity generation, and reliability improvements [4]. Liberalizing power markets will also become more important because of the advantages of pooling large generation stations, sharing spinning reserves and using the most efficient energy resources [5].

The Australian Government has initiated major funding support plans to promote commercialization of renewable energy [6]. Australia is considered one of the most favourable nations for investment in energy resource development because of low political and regulatory risks [7]. Foreign investment is welcomed by the Australian Government and no mandatory local equity or local content requirements are imposed on energy resources development [8]. The Office of the Renewable Energy Regulator (ORER) in Australia administers the Renewable Energy (Electricity) Act 2000 (the Act), the Renewable Energy (Electricity) Charge Act 2000, the Renewable Energy (Electricity) (Small-scale Technology Shortfall Charge) Act 2010 and the Renewable Energy (Electricity) Regulations 2001 (the regulations) to increase renewable electricity generation from Australia's renewable energy sources by encouraging the generation of an additional 45,000 GWh of renewable energy per year by 2020 [9]. The Australian Government has established the Renewable Energy Target (RET) scheme to ensure that 20 per cent of Australia's electricity supply will come from renewable sources by 2020. The plan is to make the amount of energy coming from sources like solar, wind, wave and geothermal sources be around the same as all of Australia's current household electricity use [10].

The Australian Government has assisted consumers with the cost of installing solar panels on Australian homes and connecting them to the utility grid for energy commercialisation purposes ($SmartGrid$) [6]. Although photovoltaic cells are still too expensive to compete effectively with the conventional power generators, the solar-cell market in Australia is expanding rapidly. Australia has a long history of using wind power for pumping water, and now it is been used widely for renewable power generation. Solar and wind systems are appropriate in Australia because of environmental concerns with conventional energy generation, usually based on burning coal, and a reluctance to adopt nuclear power or build more hydro electricity dams [11]. Solar and wind energies are popular because they are widely distributed, climate-benign, and have clean-attributes that no other major energy source can currently match. This paper is investigating the economic and environmental impacts of integrating solar and wind energies to upgrade medium size enterprise power systems for current grid and smartgrid connections.

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II. Government schemes for emissions reduction and promotion of renewable energy source uptake

The Australian Government has taken on responsibility for reducing the carbon pollution in all its states and territories. Its main target is reducing Australian's carbon footprint by nearly one third to one half. They have also started to develop new policies and rules which are needed to help Australian businesses and households to reduce their carbon pollution [12].

A. Emissions reduction and investing in clean energies

Given that Australia has a very large ecological footprint, which is dominated by carbon dioxide emissions from fossil funds, it is appropriate that Australia to be very active in responding to climate change. This indicates major research and initiative project funding for energy balance and emissions reduction, for example the Low Emission Technology Demonstration Fund (LETDF) to support the Australian firms to commercialize low emissions technologies [13]. Carbon Pollution Reduction Scheme (CPRS) would introduce a price on carbon pollution and ensure that all businesses take this into account when they developing their business plan. Concurrently, the Australian Government is developing, commercialising, and investing on clean energy technologies [12]. These will be crucial for Australia's efforts to reduce its carbon pollution emissions. These technologies will also be important to the rest of the world as they also need to reduce their carbon pollution. Australia's RET goal will be met from renewable sources such as wind, solar and geothermal power by 2020. The Initiative will create more jobs in clean industries by giving investors the confidence to back low emissions technologies such as solar power, energy from 'hot rocks' in the earth's crust, and carbon capture and storage.

B. *SmartGrid* in Australia

In the state of New South Wales, the city of Newcastle is currently starting the first commercial-scale *SmartGrid* project. The governmental initiatives for such projects will help Australians save energy, commercialize renewable energy grid connection and tackle climate change. The aim is to optimise energy participation from local generation to the public grid. *SmartGrid* will involve soft computing and distributed control systems implementation to perform demand prediction, smart renewable energy participation and distribution generation management. New market schemes and economic energy generation can be performed from applying smart infrastructure on the energy grid. It is a substantial foundation for developing smart energy markets, and it allows public, private and business sectors to interconnect the small scale, on-site generators e.g., diesel and renewable energy resources, to participate in these markets.

III. Planning for Project Development

A main problem for project development is the availability of installation space. A sufficient share for renewable energy supply requires a high number of generation units located within new or existing facilities or at more remote installation sites. There is still an alternative solution for solving installation space problem, which is increasing utility grid share in such a way, it fits with utilizing all the available space in the project land, then supplying the rest from utility grid. *SmartGrid* connection is another planning consideration. Since *SmartGrid* is a foundation for commercializing energy suppliers, it will be a key solution for solving the installation space problem. *SmartGrid* will allow the private sector to feed energy into the public grid. The energy consumers will be able to get the energy back from the *SmartGrid* from different substations in different locations covered by *SmartGrid* connection. Selling and buying energy to and from the grid from different locations will add other expenses, which will be economically analysed and added to the project cost as it is explained in the Economic Analyses section in this paper. Figure 1shows the proposed planning strategy for adding renewable energy sources to an existing microgrid.

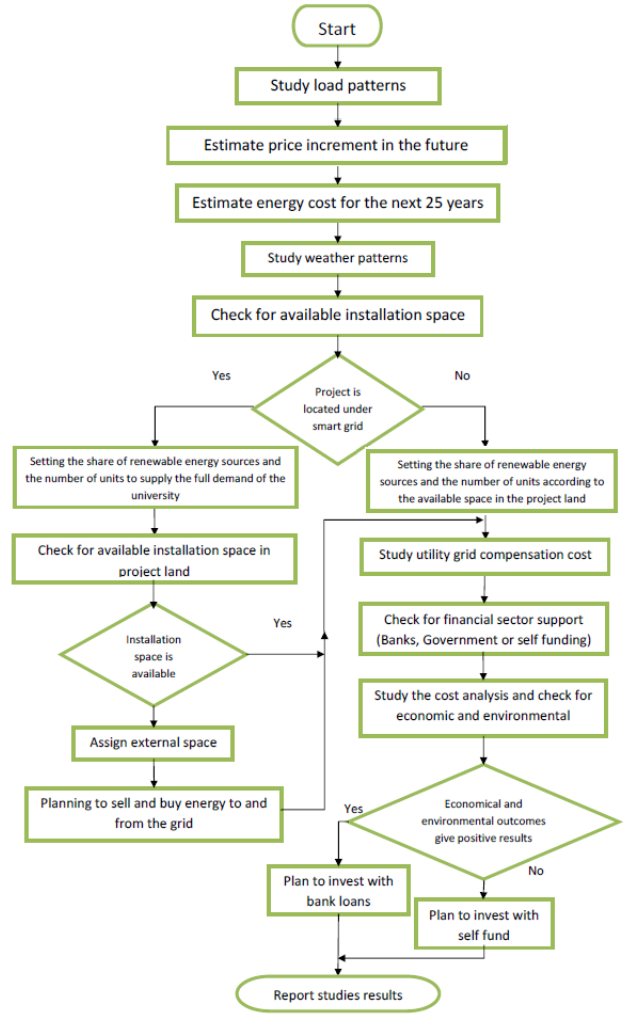

Figure 1. Project developement planning flowchart

IV. A CASE STUDY

As a case study, ECU's Microgrid at its Joondalup campus was selected for project development planning. The average climate from minimum to maximum values and safety considerations are considered in the studies. The city of Joondalup is located in one of the worlds five Mediterranean climate zones.

The geographical information for this city:
Country: Australia
State: Western Australia
City: Joondalup
Latitude: 31.44 °S
Longitude: 115.45 °E
Elevation / Altitude: 25 m
Average solar irradiation: 5.35 kWh/m²/day
Average wind speed: 12.24 km/h

The above details are helpful in detailing the installation challenges and solutions with solar panels and wind turbines. For maximum output, solar-electric (photovoltaic; PV) modules or solar thermal collectors need to be located where they receive the most sunshine. Ideally, hills, trees, buildings, or other obstructions should not shade a system site at any time during the year, so identifying the best place is complex.

Based on the university's energy demand readings, the highest amount of demand per hour occurs on summer's afternoons, reaching 1704 kWh, while the lowest energy occurs on winter nights or holidays, (284 kWh). To cover the demand in the university, a specific number of solar panels and wind turbines are needed. As the highest demands are always during the day time, more emphasis would be placed on solar panels rather than wind turbines.

A. Solar panel installation

According to the provided information about the climate in the city of Joondalup and generation efficiency of different brands of solar panel, generation outcomes were estimated. For best generation outcomes, the installation angles of the solar panel have to be adjusted according to the location of the project, and the angle of the sun during winter and summer seasons. To optimize the installation of solar panel in the city of Joondalup, the angle is adjusted to 23^o, facing north, (Fig 2).

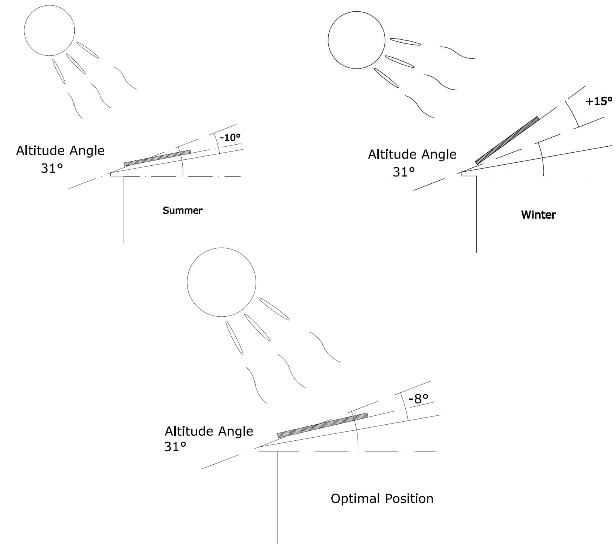

Figure 2. Summer, Winter and Optimal Angles for Solar Panel Installation

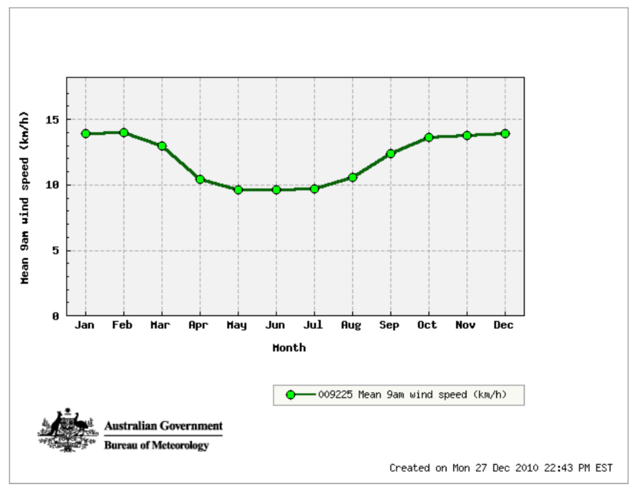

Figure 3. Average Monthly Wind Speed in the City of Perth

From the installation and sun angle challenges, the average lost generation for solar panel was estimated to be about 10% of the overall annual generation capacity. For the selected solar panel unit, the average daily solar panel output is estimated at 936 Wh, while the monthly average of minimum and maximum daily solar panel output is 439 and 1447 Wh respectively. The average annual solar panel output is 341 kWh. For 25 years, the total solar panel output will be about 8.525 MWh. Based on these calculations, this unit is considered appropriate for ECU's microgrid energy supply.

B. Wind turbine installation

In wind energy, useful energy contribution (work) is calculated by summing the amount of generated power over time taking into account variation in wind and operational conditions. The relationship between the size of the wind turbine and the generation outcomes may vary depending on the threshold point for wind speed and the amount of available wind speed annually. From the climate study results, it has been shown that wind speed drops to zero regularly from midnight till sunrise. The average wind speed is 12.24 km/h while minimum and maximum (monthly average) wind speeds are 9.36 km/h and 15.84 km/h respectively. The minimum wind speed to activate generation in the nominated unit is 9 km/h. For a secure power supply design, utility supply will cover the missing hours of generation availability for solar panels and wind turbines. The wind speed readings were collected from City of Perth station, which is located about 20 km south from the project location.

As a conservative estimation, the average monthly 9 am wind speed for the city of Perth since 1993 is illustrated in Fig. 3.

From the climate study, the safe estimated average of

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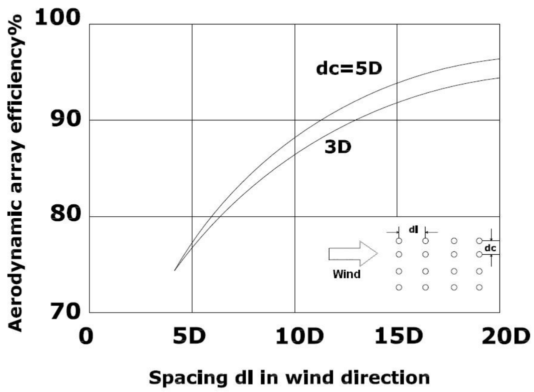

Figure 4. Aerodynamic array efficiency as a function of rotor distance in the wind direction [14], whre D is the wind turbine rotor diameter, dl is the space length between the two installed wind turbines in project land, and dc is the space width between the two installed wind turbines in project land.

missing wind generation hours varied between 20 hours in winter season and zero hours per day in summer season. For wind turbine, the technical layout and design of wind park installations are important. When installing several wind turbine concentrated in an array, the major challenge which arises is the spacing. The relationship between rotor distance and aerodynamic array efficiency is illustrated in Figure 4. A minimum clearance between the wind turbines must be guaranteed, otherwise power losses will be so high that the wind park will operate uneconomically.

This influences the required space needed for this project at Joondalup, where space can be limiting. However, for the $SmartGrid$ connection, an off-campus location is used and land cost becomes a factor.

V. Economic Analyses

Economic analyses for installing DERs for this project were conducted for conventional grid and $SmartGrid$ connections.

A. Conventional grid connection

For this project, a satellite image for the project's land has been added to identify available installation space. For this project, it has been found that the available installation space for the wind turbine is 17000 m² as shown in Figure 5. Adding to that, sufficient installation space has been allocated for solar panel installation.

From the climate study, and the characteristics of the project land, it has been estimated that solar panels and wind turbines can share the supply of 37% of the full electricity demand in the university. The 37% generation is set to be 85% from solar panels and 15% for wind turbines. Figure 6 is showing the assigned energy supply shares of the installed DERs.

From the current 2,000 kWh maximum daily demand, and the assigned 85% of the solar panel participation in the 37% share of DERs supply to the project, 735 kWh is required to be generated from solar panels. This can be obtained by

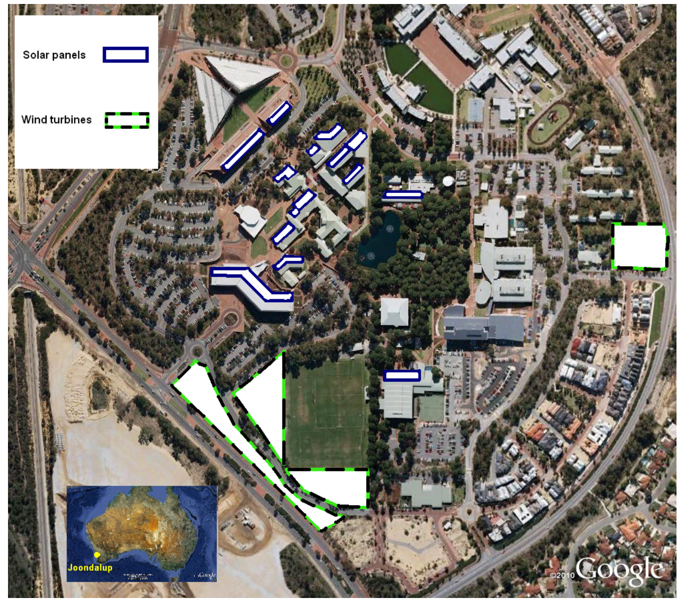

Figure 5. Satellite Image for the project plan

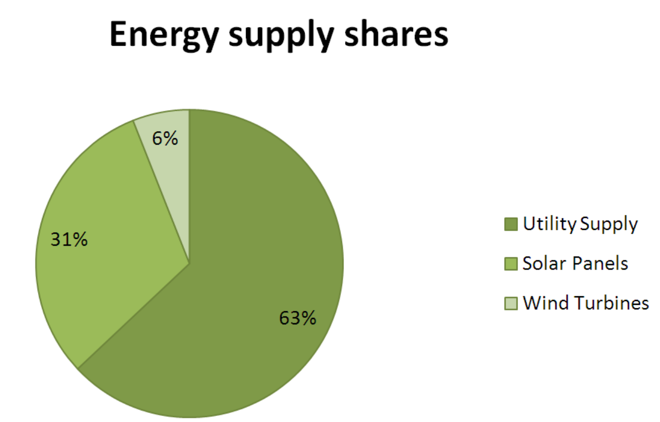

Figure 6. Proposed energy supply shares for ECU power system for the conventional grid connection

installing 3964 units of the in-market selected units "*Sharp NUS5E3E 185 W mono*". Each single unit required 1318 x 994 x 46 mm for installation space. Thus, for the needed number of solar panels, 5193.2 m² is required. For Wind turbine, the nominated generation unit is "WinPower 48V DC/240V 2000Watt", which has a 4 m rotor diameter. The required installation space is 300 m² for each wind turbine, allowing for the 56 wind turbines for this project. So, for both solar panel and wind turbine installation area, about 21,193 m² will meet the required installation space.

Other calculation assumptions for the missing generation hours due to clouds and low speed wind have to be considered under generation capacity for the installed renewable energy sources. The average calculated missing hours of generation are summarised in Table I.

These have to be compensated by utility grid supply and Tables II and III show the amount of non operating hours and the energy compensation needed from the utility grid

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Energy Source\Time mode	Day time (8:00-17:00)	Night time (17:00-800)	Total missing hours
Wind turbine	3 hours	7 hours	10 hours
Solar panel	2 hours	13 hours	15 hours

Table I
THE DAILY AVERAGE OF MISSING GENERATION HOURS

Time mode\parameters	Daily consumption	Assigned share	Missing operation	Utility compensation
Day time (8:00-17:00)	12311 kW	3816 kW	2 hours	848 kW
Night time (17:00-8:00)	7566 kW	2346 kW	13 hours	2033 kW

Table II
CONVENTIONAL GRID SOLAR PANEL MISSING OPERATING HOURS AND UTILITY COMPENSATION

Time mode\parameters	Daily consumption	Assigned share	Missing operation	Utility compensation
Day time (8:00-17:00)	12311 kW	739 kW	3 hours	246 kW
Night time (17:00-8:00)	7566 kW	454 kW	7 hours	212 kW

Table III
CONVENTIONAL GRID WIND TURBINE MISSING OPERATING HOURS AND UTILITY COMPENSATION

under conventional grid connection. The average total daily utility compensation is 3,125 kW. Since the total annual energy consumption is 6,082,854 kW, the average daily consumption is about 16,666 kWh. Thus, the average daily utility compensation for the non-operating hours is 18.1% adding to that the actual 63% utility supply for the university. Then, the actual utility for the project will be 81.5% and the renewable energy participation will be 19% of the total needed generation. Table IV shows the details of the missing operation hours of the installed solar panels and wind turbines.

Additional weather studies have been applied to show the generation outcomes and the amount of non-operating hours shares. Figure 7 shows the shares of the proposed number of generation units and the non operating hours for renewable energy sources under conventional grid connection.

Time mode\Generation unit	Solar panel	Wind turbine	Total
Day time	734 kW	195 kW	929 kW
Night time	2029 kW	167 kW	2196 kW
Total	2763 kW	362 kW	3125 kW

Table IV
AMOUNT OF NON-OPERATING HOURS ENERGY

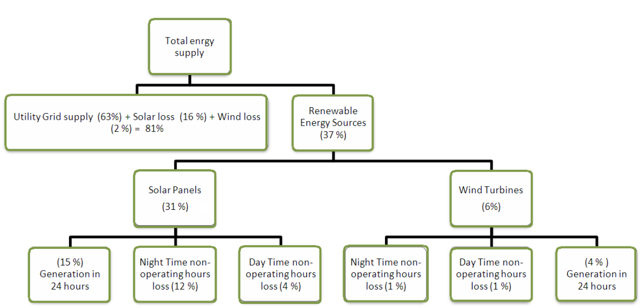

Figure 7. Energy supply shares for the proposed project under conventional grid connection

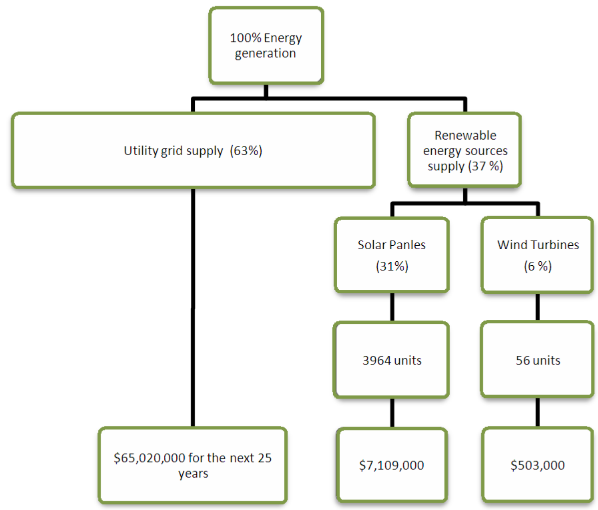

Figure 8. The distribution of generation shares for utility and renewable sources under conventional grid connection

Generation unit\details	Capital costs	Operating costs	Total
Solar panel	$3,554,559	$3,554,559	$7,109,118
Wind turbine	$251,563	$251,563	$503,126
Total	$3,806,122	$3,806,122	$7,612,244

Table V
CONVENTIONAL GRID CONNECTION RENEWABLE ENERGY SOURCES INSTALLATION COST[14]

For solar panel, the estimated generation price for 25 years from this unit was found to be between 0.0288-0.0354 \$/kWH according to "$SharpNUS5E3E185Wmono$". For wind turbine, the equivalent is about 0.07\$/kWh generation price over 25 years. The utility energy prices may increase for the next 3 years by 10% and may increase by another 90% by the next 25 years. The estimated cost that ECU is currently paying is about \$2,140,594 a year. Thus, for the next 25 years with energy price increment, it is expected that ECU is willing to pay about \$80,272,000 over 25 years if all assumptions are realised. For these calculations, load expansion will not be considered for generation capacity installation.

From the calculations of the renewable energy generation shares, it is expected that ECU will have to pay \$65,020,000 in the next 25 years. Figure 8 shows the proposed generation shares of the renewable energy sources and utility grid supply for the proposed project.

Thus, the total generated energy by solar panels and wind turbines for this project will cost \$7,612,244 for the next 25 years. The total cost savings will be \$7,639,494. Table V details the estimated cost of installing and operating the DERs for the investigated project.

Note that, capital costs include the modules costs, while the

Generation unit\details	Capital costs	Operating costs	Total
Solar panel	$7,568,000	$7,568,000	$15,136,000
Wind turbines	$1,349,000	$1,349,000	$2,698,947
Total	$8,917,00	$8,917,00	$17,834,000

Table VI
SmartGrid CONNECTION RENEWABLE ENERGY SOURCES INSTALLATION COST[14]

operating costs include converters, installation, maintenance, engineering consultation and insurance costs. Investigating the financial support from the finance sectors, the Australian Government promotes funding one third of the project budget, which will save about $2,537,414. The current loan rates are 7.1% for fixed annual interest. For the specified project, that all funding is borrowed except for Australian Government funding support, ECU will need to invest about $5,074,828 on this project. To refund this amount after 25 years, it required to pay extra $5,762,724 according to current Australian banks loan rates. Figure 11

From the above calculations , it has been conducted that: from the economic analyses point of view, this project will save about $4,414,189 including the $2,537,414 of Australian Government support. These calculations were to evaluate the investment values in 25 years time in case of loan funded scenario. In case of self funded scenario, the project will save about $10,176,910 including the Australian Government funding support, ignoring the opportunity costs for other uses of ECU funds.

B. *SmartGrid* connection

Future *SmartGrid* will have fair solutions for installation area problems. For this case study, this project can be implemented on a remote area covered by *SmartGrid* power lines. *SmartGrid* will allow private sectors to feed-in the energy to the public grid. The energy consumers will be able to have the energy back from the grid to supply their loads from wherever it is covered by *SmartGrid*. The difference in prices for selling and buying to and from the grid from different locations will be added to the project cost. Since installation space problem can be solved by *SmartGrid*, the full capacity generation will be supplied by renewable energy sources for the specified project rather than having a nett reliance on the utility grid supply. Thus, it is assigned to have the 2,000kWh from the renewable energy sources (70% for solar panel and 30% for wind turbine).

Due to missing operation hours of the renewable energy sources as shown in table I, utility grid compensation is considered under economic analyses to compensate for the missing operation hours. From the current 2,000 kWh maximum daily demand and the 70% solar panel with 30% of wind turbine generation share, it is required to install 7568 units of the above nominated solar panel type and 300 units of the nominated wind turbine type (Figure 9).

Table VIIllustrates the renewable energy source installation costs for the *SmartGrid* connection case.

Figure 10 shows the proposed energy supply shares and the non operating hours for the assigned renewable energy sources.

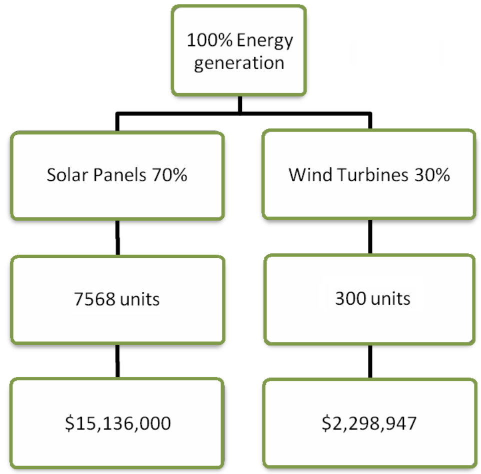

Figure 9. The distribution of generation shares for utility and renewable sources under *SmartGrid* connection

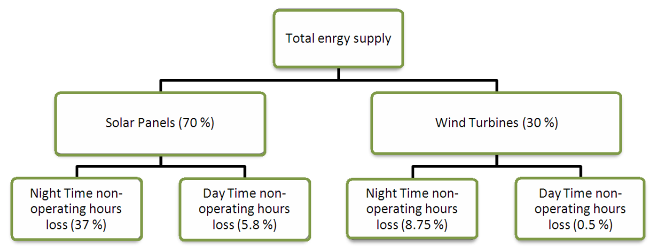

Figure 10. Energy supply shares for the proposed project under *SmartGrid* connection

Table VII and VIII show the non operating hours details and the amount of energy to be compensated from the utility grid for *SmartGrid* connection case. From tables VII and VIII it has been estimated that the estimated utility grid compensation for the missing operating hours of renewable energy sources is about: 7728 kW per day (24 hours). The utility compensation price for the 25 years is expected to be: $21,155,400. Thus, price difference of selling and buying to and from the grid, may cost an extra $11,085,962. The needed installation space for this project may cost $7, 500, 000 as well assuming that this location will have the same climate characteristics as those estimated for Joondalup, according to current Australian land prices. The total project cost may reach to $64,518,551 including the Australian Government support in case of fully loaned project. Thus, the project may save up to $15,753,751 in case of fully loan funded project, while it may save up to $32,277,190 including the Australian Government support a self funded project, ignoring the opportunity for cost associated with alternative uses of ECU's funds.

Time mode\parameters	Daily consumption	Assigned share	Missing operation	Utility compensation
Day time (8:00-17:00)	12311 kW	8618 kW	2 hours	1915 kW
Night time (17:00-8:00)	7566 kW	5296 kW	13 hours	4590 kW

Table VII
Smartgrid SOLAR PANELS MISSING OPERATING HOURS AND UTILITY COMPENSATION

Time mode\parameters	Daily consumption	Assigned share	Missing operation	Utility compensation
Day time (8:00-17:00)	12311 kW	3693 kW	3 hours	1231 kW
Night time (17:00-8:00)	7566 kW	2270 kW	7 hours	1059 kW

Table VIII
$Smartgrid$ WIND TURBINE MISSING OPERATING HOURS AND UTILITY COMPENSATION

Generation unit\Values	Daily generation	CO_2emission/MWh	CO_2mitigation/MWh
Wind turbine	579 kW	9 kg (21.7 lb)	242.86 kg (555.84 lb)
Solar panel	2567 kW	282 kg (623.7 lb)	1834.64 (1840.62 lb)
Total	3146 kW	291 kg (645.5 lb)	2077.5 kg (2396.46 lb)

Table IX
THE AMOUNT OF MITIGATED CO_2 BY RENEWABLE ENERGY SOURCES UNDER CONVENTIONAL GRID CONNECTION

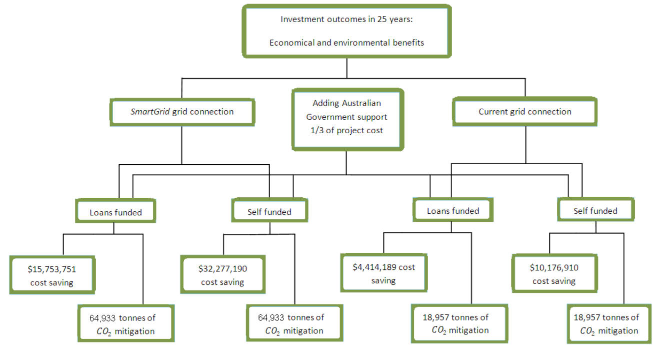

Figure 11. Investment economic and environmental benefits

VI. ENVIRONMENTAL ANALYSES

Solar panels are generating power with no noise and very low rate of emissions including those involved in manufacturing, transporting and installing the panels. The main environmental effects caused by wind turbine generation are: audible sound, infrasonic sound, disco effect, shadow impact, ice throw, visual interference with natural scenery, harm to bird-life, effects on other fauna, space consumption, offshore utilisation and social acceptance [15]. However, photovoltaic power plants emit 110 kg (243 lb) CO_2/MWh, while wind turbine plants are emitting 17 kg (37.5 lb) CO_2/MWh. By comparison: modern gas and steam turbine power plants emit 435 kg (960 lb) CO_2/MWh, while coal-fired power plants to emit 900 kg (1980 lb) CO_2/MWh [15]. From this project, tables IX and X show the amount of daily generation and CO_2 mitigation by solar panels and wind turbines for conventional grid and $Smartgrid$ connections.

Evaluating the importance of this project for the next 25 years, it is expected that this project will save 18,957 tonnes of CO_2 emission for conventional grid connection, and 64,933 tonnes of CO_2 for $SmartGrid$ connection. This average value is based on CO_2 release from modern gas and steam turbine and coal-fired power plants. Figure 11 provides the estimated investment benefits for this project under self funded and loan funded cases for conventional grid and $SmartGrid$ connection.

VII. CONCLUSIONS

Upgrading ECU's power grid with DERs installation has been described and costed this paper. There are great challenges in installing the estimated amount of DERs in terms of allocating suitable installation space and investigating the non operating hours of DERs based on the weather patterns at the project location. Economic and environmental impacts were investigated for this problem in this paper. The economic analyses have shown that the project may achieve different amount of profits including the Australian Government fund support under different connection modes: conventional grid or $SmartGrid$, and may vary according to the sponsored fund from financial sectors. The calculations showed that for best economic and environmental benefits, it is more beneficial to implement this project with $SmartGrid$ connection. From these calculated results, it is noticed that it is encouraging to invest on upgrading medium size enterprise power system projects with these friendly conditions.

Generation unit\Values	Daily generation	CO_2emission/MWh	CO_2mitigation/MWh
Wind turbine	3673 kW	63 kg (21.7 lb)	2390 kg (555.84 lb)
Solar panel	8476 kW	933 kg (623.7 lb)	4726 kg (1840.62 lb)
Total	12149 kW	996 kg (645.5 lb)	7116 kg (2396.46 lb)

Table X
THE AMOUNT OF MITIGATED CO_2 BY RENEWABLE ENERGY SOURCES UNDER $SmartGrid$ CONNECTION

REFERENCES

[1] B. Roberts, "Capturing grid power," *Power and Energy Magazine, IEEE*, vol. 7, no. 4, pp. 32–41, 2009.
[2] C. W. Joel Makower, Ron Pernick, "Clean energy trends 2009," *available on http://www.cleanedge.com/reports*.
[3] S. Honkapuro, "Business impacts and incentives of regulation for dsos and smart grids," in *Electricity Distribution - Part 2, 2009. CIRED 2009. The 20th International Conference and Exhibition on*, pp. 1–10, 2009.
[4] D. Novosel, "Emerging technologies in support of smart grids," in *Power and Energy Society General Meeting - Conversion and Delivery of Electrical Energy in the 21st Century, 2008 IEEE*, pp. 1–2, 2008.
[5] D. R. C. U. M. W. W. Breuer, D. Povh, "Prospects of smart grid technologies for a sustainable and secure power supply," tech. rep., World Energy Council, 2007.
[6] Australian-Governmentl, "Smart grid, smart city," *available on http://www.climatechange.gov.au/government/programs-and-rebates/smartgrid.aspx*.
[7] O. of-the Renewable-Energy-Regulator, "Legislation," *available on http://www.orer.gov.au/legislation/index.html*.
[8] Australian-Government, "Securing australia's energy future," *available on http://www.efa.com.au/Library/CthEnergyWhitePaper.pdf*.
[9] D. of-Climate-Change-and Energy-Efficiency, "Renewable energy target," *available on http://www.climatechange.gov.au/government/initiatives/renewable-target.aspx*.
[10] WAtoday, "renewable-energy-tariffs-announced," *available on http://www.watoday.com.au/wa-news/renewable-energy-tariffs-announced-20100527-wgnn.html*.
[11] P. Hu, R. Karki, and R. Billinton, "Reliability evaluation of generating systems containing wind power and energy storage," *Generation, Transmission and Distribution, IET*, vol. 3, no. 8, pp. 783–791, 2009.
[12] Australian-Government, "Reducing australia's emission," *available on http://www.climatechange.gov.au/government/reduce.aspx*.
[13] D. of-Resources-Energy-and Tourism, "Low emissions technology demonstration fund," *available on http://www.ret.gov.au/energy*.
[14] E. Hau, *Wind Turbines: Fundamentals, Technologies, Application, Economics*. Berlin: Springer, 2006.
[15] A. S.-A. W. Martin Kaltschmitt, Wolfgang Streicher, "Renewable energy: Technology, economics and environment," 2007.