AQUAMARINE POWER

PRODES

Promotion of Renewable Energy for Water production through Desalination

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Renewable Desalination Market Analysis:

Oceania, South Africa, Middle East & North Africa

ProDes Project
Work Package 5
Task 5.4
Export Market Analysis

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FOREWORD

The ProDes project (www.prodes-project.org) brings together 14 European organisations that work together to support the use of Renewable Energy (RE) Desalination technology, particularly for off-grid communities with water scarcity and energy infrastructure issues. At present the main RE technology options for powering desalination (reverse osmosis or distillation technologies) are: solar thermal, concentrated solar power, photovoltaic, wind power, geothermal energy and ocean energy. The overall aim of the project is to support and promote the dissemination of RE-Desalination technology by effectively interacting with the following bodies: research institutes, universities, industry, small to medium size enterprises (SMEs), investors, public authorities and decision makers and civil society.

Work package 5 of the ProDes Project aims to mobilise investment. This will involve communicating to the private and public investment community that RE Desalination technology is a potential and viable resolution to issues of water scarcity and climate change. Generating investment to provide the funding gap between start up technologies through to commercially viable projects is the key challenge.

Aquamarine Power Ltd, Scotland, is a member of the ProDes consortium and has been asked to investigate task 5.4: Export Market Analysis (outside the EU). Three potential international desalination markets have been studied for export opportunities these include: the Middle East and North Africa (MENA) region, with a profile on Morocco; the OCEANIA region, with a profile on Australia; and SOUTH AFRICA, with an in-depth report.

These regions and countries have been selected because they are experiencing water scarcity and climate change issues. Each report provides details on the economic and governmental structures, the power sector, renewable energy legislation, the water sector, recent investment and a summary of the renewable desalination market potential. The overall aim has been to immerse RE-Desalination developers in the economic, regulatory and market operations of each region so they can develop a balanced market view on the potential exportation opportunities.

CONTENTS:

INTRODUCTION

Three different regions of the world are analysed to determine the potential for the development of renewable energy desalination projects. These regions are Oceania, South Africa and Middle East & North Africa (MENA). Each region is analysed independently without reference to the other regions and so this report is organised into three sections, one for each of the regions.

A short executive summary is provided for each region, which provides a synopsis of the contents of the section, focusing on the potential for the development of renewable energy desalination projects. Following each executive summary is an overview of the region, providing details of its geographical extent, demographics and other aspects of interest to put the analysis in context. The next two chapters look at the regions energy and water sectors respectively. These two chapters provide a more detailed investigation into the key sectors in which renewable energy desalination projects will have to operate.

The next chapter looks at the funding and investment within the particular region. This is particularly important for renewable energy desalination projects because in many cases additional funding will be required in the project to support the development of the emerging technologies. The next chapter looks at the renewable energy resources in the region, helping to indicate the type of renewable energy that is available in the region. This is followed by a chapter on the desalination sector in the region, providing details on the amount of desalination capacity of the region and the existence of any renewable energy desalination projects, which can help to indicate the general support for such projects in the region.

For the Oceania and MENA regions the final chapter contains a detailed analysis of a single country in the region, Australia and Morocco respectively. This provides a more in-depth look at the potential for renewable energy desalination projects for each particular country. The section on South Africa simply contains a chapter on the potential of the renewable energy desalination market in South Africa.

Oceania

EXECUTIVE SUMMARY

Oceania is a very diverse region containing highly developed countries such as Australia as well as the less developed Pacific Island nations. Although in some countries there is little water scarcity, e.g. New Zealand, in general the region suffers from a lack of fresh water. Therefore, there is a high demand for desalination projects in the region which is supported politically due to concerns regarding the impact of climate change. This support stems from a variety of perspectives ranging from an egalitarian perspective in Australia, where the highly educated population recognise that climate change will be problematic, to the more immediate concerns of the low-lying pacific islands where climate change could result in them disappearing within the next century. A consequence of this political support is that there are a large number of sources of potential funding for renewable energy desalination projects, which are in many cases supported by government targets.

The diversity of the region is matched by the diversity of potential renewable energy desalination projects. Although there is some variation across the region, there is in general a good supply of renewable energy including solar, wind and wave power. Large-scale projects are supported for municipal water supplies, where the presence of a firm electricity grid mean that the renewable energy and desalination processes do not need to be intimately tied together. There is also potential for small-scale projects for off-grid water supplies because of the large number of off-grid communities. Furthermore, suitable small-scale projects may range from technologically complex solutions for remote Australian communities to less complex solutions for communities on the smaller pacific islands.

1. OVERVIEW OF OCEANIA

The Oceania region includes Australia and New Zealand as well as a collection of small, island states scattered across the Pacific Ocean. These states vary considerably in size and geography; from low lying coral atolls, to mountainous volcanic islands, to the large land masses of Australia and Papua New Guinea.

Oceania has a diversity of water resource characteristics such as: New Zealand, which has a plentiful but somewhat mismanaged resource; the Island States which require improved infrastructure and are experiencing an increase water scarcity; and finally, Australia which has very advanced infrastructure in place to cope with impending water shortages. These nations are all concerned about the effects of climate change and future water scarcity. They have therefore developed sustainable development strategies for energy and water management. The challenge they face is approaching these problems with administrative cohesion across the region.

The Pacific Islands have many rural, off-the-grid communities where 50% of the population does not have access to safe drinking water[1] however; this is interspersed with island tourist resorts that have good quality water which is largely supplied by desalination developers from wealthier nations such as Japan and Australia. The Pacific Islands also enjoy much financial and technical support from Australia and New Zealand, as well as many other developed nations globally[2]. The majority of the Pacific Island population live on the coast and are dependent on the fishing and tourist industries. The urban population of the Pacific Islands is set to rise and this will only exacerbate the already scarce supply of clean water thus putting more strain on government finances to provide affordable desalination technologies.

The South Pacific Forum is composed of 14 island countries with a combined population of 6.4 million. Amongst these islands there is a huge diversity in language, culture and government systems. The forum brings the benefits of knowledge-sharing on all levels to enhance economic development and a powerful voice of representation in a global setting. There are various regional organisations within this forum such as: the Secretariat of the Pacific Community (apolitical services), the Forum Fisheries Agency and the University of the South Pacific (with branches in each country to develop research).

The Pacific Islands Development Programme (PIDP) conducts a broad range of activities to enhance the quality of life in the Pacific Islands including the American Pacific Islands. They aim to achieve and sustain equitable social and economic development that is consistent with the goals of the Pacific Island’s indigenous people. PIDP began as a forum through which island leaders could discuss critical issues of development with a wide spectrum of interested countries, donors, non-governmental organisations, and the private sector. Today, PIDP's role as a regional organisation has expanded to include the following remit: Island leader conferences, a joint commercial commission, research and dialogue, educational training and news updates[3]. The Canada-South Pacific Ocean Development Programme provides funds for ocean development projects.

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1 http://www.childinfo.org/water_oceania.htm

2 Terry, J., Kahsai, K, et al (Dec 2005) Delivering Education in Integrated Water Resources, Management across the Oceania Region, Directions: Journal of Educational Studies 27 (2) Dec 2005, http://www.directions.usp.ac.fj/collect/direct/index/assoc/D1175086.dir/doc.pdf

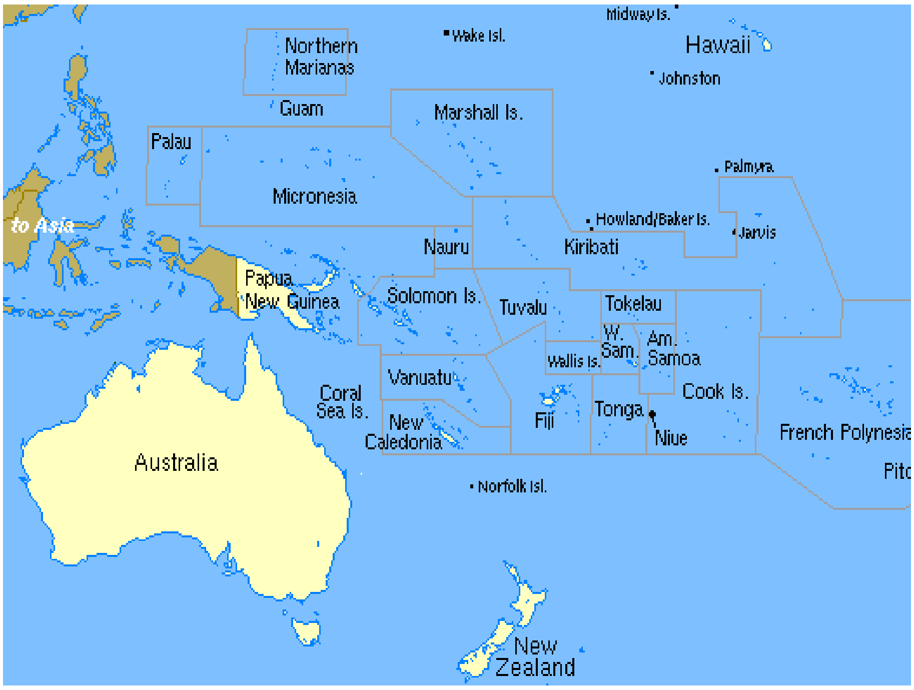
3 http://www.eastwestcenter.org/pacific-islands-development-program/

The two forums of specific interest are the South Pacific Regional Environment Programme (SPREP), established to coordinate on environmental matters, and the South Pacific Applied Geosciences Commission's (SOPAC), which has the overall mandate to develop mineral exploration and regional responsibility for the water and sanitation sector. The Island governments do not have the resources to conduct expensive research programmes or environmental projects such as Water Resources Surveys without overseas funds and expertise.

The government agencies need to mirror the current strategies of regional organisations by providing advice and technical support to their "member" provinces and villages[4]. Members of the Pacific Islands forum have also endorsed the Pacific Regional Free Trade Agreement (PARTA) in an attempt to improve their economies. The forum also benefits from European Union staff to assist with various projects including cyclone warning systems and waste awareness and education.

The members of the **South Pacific forum** are listed below: Australia

Cook Islands	Micronesia	Fiji Islands
Kiribati	Nauru	New Zealand
Niue	Palau	Papua New Guinea
Marshall Islands	Samoa	Solomon Islands
Tonga	Tuvalu	Vanuatu



Map 1: Oceania Region [5]

4 Tell Consultants (2009) Participatory integration of planning and policy makinghttp://www.tellusconsultants.com/planning.html

5 www.google.co.uk/maps

2. OCENIAN ENERGY SECTOR

The demographics, infrastructure and geography make power supply a complex issue. The Pacific Islands has virtually no indigenous fossil fuel reserves, apart from Papua New Guinea and Timor which have natural gas power plant. Hydropower is only located on the larger islands and currently renewable energy makes up 10% of the active generation capacity.

The Pacific region's fossil fuel consumption contributes very little to the global greenhouse gas (GHG) emissions, however all islands rely heavily on imported fossil fuels. They have an evolving framework for energy development which must be addressed in order to provide greater security of power. In many of the nations, the energy, transport and ports infrastructure require further development in order to shift reliance on imported fossil fuels to indigenous, economically beneficial power systems[6].

3. OCEANIAN WATER RESOURCE AND MANAGEMENT

The Pacific Ocean has many climate uncertainties with inter-annual variations such as the El Niño–Southern Oscillation therefore predicting the impacts of climate change is difficult. General predictions incorporate a rise in sea levels, more frequent tropical storms, prolonged drought and bleaching of coral reefs.

Specific national strategies and action plans are required for each island[7] due to the variations in water resources. For the volcanic and mountainous islands, where the water resource is plentiful, improved management systems are required in order to store and distribute water. For islands that have no natural water capture features, exploitation of new water resources is required.

Climate change is expected to result in scarcity of freshwater resources, increased salinity of soils and declining fish stocks. This poses food and economic insecurity to the pacific region. Water intensive agriculture practices, increased water borne diseases, population and tourism growth are all increasing the need for potable water.

The 'Water for Small Island Countries' sessions at the World Water Forum, Kyoto 2003, highlighted key concerns for the Pacific Island nations such as: lack of natural storage for water, dispersed populations, lack of water infrastructure and competing land uses (particularly on smaller islands). In addition, the lack of cohesive water resource management combined with restrained funding and skills in the water service provider sectors compounds the problem.

6 ABD (2009) Climate Change Implementation Plan for the Pacific (2009-2015), http://www.adb.org/Documents/Books/Climate-Change-Implementation-Plan/ccip.pdf#page=14

7 ABD (2009) Climate Change Implementation Plan for the Pacific (2009-2015), http://www.adb.org/Documents/Books/Climate-Change-Implementation-Plan/ccip.pdf#page=14

In 2005, the University of the South Pacific which operates as a virtual university (based in Fiji) established the Water Virtual Learning Centre in partnership with the United Nations University and the International Network on Water, Environment and Health to provide Integrated Water Resource Management (IWRM) courses to members of the water sector. This has helped them develop strategies to cope with managing the resource. There is global support for such initiatives because the Millennium Development Goals aim to halve the population living without access to potable water and basic sanitation by 2015[8].

3.1 Water Legislation

After national consultations across the Pacific Islands, East Timor and the Maldives *The Pacific Action Plan on Sustainable Water Management* 2003 was devised. The action plan incorporates 16 Pacific Island states. This was presented at the World Water Forum, Fiji 2002, and information was gathered by the Asian Development Bank and the South Pacific Applied Geosciences Commission (SOPAC). The plan was financed by the Pacific Water Association, AusAid, the Department for International Development and NZAid. These organisations are still key stakeholders in furthering the development of water management in the Pacific, as are the national water agencies together; they aim to create a network of open participation in sustainable water and wastewater management in communities and all levels of society.

The main focal points for the *Pacific Action Plan on Sustainable Water Management Plan* are: Water Resource Assessment and Monitoring, Rural Water Supply and Sanitation, as well as Integrated Water Resource and Catchment Management. Various water monitors and skill enhancing research initiatives have been enacted with the support of SOPAC, the United Nations Educational, Scientific and Cultural Organization (UNESCO), the World Meteorological Organization (WMO) and the National water agencies. It was recognised that climate and water resources vary considerably between the islands with some having adequate resources and others needing more water to ensure growth in sectors such as tourism, agriculture, mining and human populations.

All Pacific Islands need to ensure that minimum standards for water quality monitoring and sanitation are implemented. It was also recognised that the differences between the islands need to be approached holistically in order to establish effective Integrated Water Resources Management (IWRM) and ensure sustainability of water resources. They also set out to effectively monitor rainfall and drought with a proposed Hydrological Cycle Observing System and move on from disaster

8 Terry, J., Kahsai, K, et al (Dec 2005) Delivering Education in Integrated Water Resources, Management across the Oceania Region, Directions: Journal of Educational Studies 27 (2) Dec 2005, http://www.directions.usp.ac.fj/collect/direct/index/assoc/D1175086.dir/doc.pdf

response approaches to hazard and risk assessment in order to implement concrete policy rather than just respond to disasters[9]. Status on these aims is available on the SOPAC website[10].

4. OCEANIAN FUNDING AND INVESTMENT

Monitoring of climate change will require financial and technical assistance across the region for each nation island as climate change will undoubtedly affect various key economic sectors such as agriculture, tourism and fishing. However, the complexity of regional organisations, geography and climate make assistance challenging. Most financial investment has concentrated on disaster management which has largely been unhelpful when tackling wider issues of sustainability through renewable technology and water management[11].

Areas for funding and investment in renewable and water resource initiatives in the Oceania region are multi-fold and they include: assisting with national strategy, providing training for capacity building, gathering data on resources and infrastructure, promoting development projects both large and small scale as well as facilitating knowledge sharing and networking.

The United Nations Development Programme recognises that Oceania, and in particular the island states, face challenges of remoteness in terms of economic diversification. Additionally, they are vulnerable to climate change due to their low lying elevation and as result require investment into ocean defence systems[12].

Funding for the sustainable development of the Pacific Islands comes in various forms and is largely driven by the Millennium Development Goals and disaster management scenarios. More recently, disaster management funding has moved on to ‘Adaption’ which involves cooperation between the World Bank and international governments to encourage the creation of sustainable communities, reduce reliance on fossil fuels and improve the management of water and energy resources. This comes with a particular emphasis on vulnerable countries, such as the Pacific Island states. The various development bank and International Development Agency funds available to the Pacific Islands for this purpose are listed below:

The Asian Development Bank (ADB)

ADB funds research, policy, knowledge-sharing and infrastructural developments within the energy sector. They do not consider investments in technologies such as large scale ocean energy, biofuels and geothermal power as a priority at present. They have contributed to various funds such as: the

9 Word Water Forum (2002) Pacific Regional Action Plan on Sustainable Development of Water Management, Fiji. http://www.sprep.org/att/IRC/eCOPIES/Pacific_Region/7.pdf

10 http://www.sopac.org/About+PIEPSAP

11 ABD (2009) Climate Change Implementation Plan for the Pacific (2009-2015), http://www.adb.org/Documents/Books/Climate-Change-Implementation-Plan/ccip.pdf#page=14

12 UN MDP (2010) the key elements for rapid scale-up, http://www.unmillenniumproject.org/reports/country_proc5.htm

GEF Implementing Agency Climate Change Fund, UNFCCC Adaptation Fund; Poverty Environment Fund; Water Financing Partnership Facility, the Asia Pacific Carbon Fund; Future Carbon Fund; the Clean Technology Fund and the Clean Development Fund (UN).

The Australian Agency for International Development (AusAid):

Their Adaptation to Climate Change Initiative will provide AUD$150 million over three years, they have already distributed AUD$35 million in 2008–2009. Their aid emphasis is on Pacific Island countries and East Timor; small grant schemes in Fiji, Samoa, Solomon Islands, Tonga and Vanuatu; Pacific Islands Climate Prediction Project; Coral Triangle Initiative.

Global Climate Change Alliance:

€50 million to provide assistance in the following five areas:

- Implementing concrete adaptation measures
- Reducing emissions from deforestation
- Assisting less developed countries to trade on the global carbon market
- Preparing less developed countries for natural disasters
- Integrating climate change into development cooperation and poverty reduction strategies.

Global Environment Facility (GEF)

GEF aims to create the ability to leverage significant funding for mitigation and, increasingly, for adaptation to climate change.

Germany:

A new regional programme, Adaptation to Climate Change in the Pacific Island Region, started in January 2009 and will be a significant source of co-financing and direct financing, with focus on adaptation. Possible cooperation on adaptation mitigation opportunities will be implemented in Fiji, Tonga, and Vanuatu during the next four years. The main focus of the programme lies on building capacities of people and institutions for adaptation measures regarding land-based natural resources. The overall contribution of the German government is €4.2 million.

Italy and Austria:

These two nations provide funding for the Sustainable Energy Programme for the Pacific Small Island States, part of which is managing the ecosystem and livelihood implications of energy policies in the Pacific Island states. This is the Pacific component of the World Conservation Union Energy, Ecosystems and Sustainable Livelihoods Initiative.

Japanese Bank for International Cooperation (JBIC):

Their Office for Climate Change was established in 2008 to assist with co-financing for institutional strengthening in the Pacific along with the Asian Development Bank (ADB)

New Zealand Agency for International Development (NZAID):

Focus on funding adaption mainly through water management and institutional support.

United Nations Development Programme (UNDP):

UNDP will support the Pacific region for both existing and new initiatives to adopt integrated and sustainable human development, the proposed centre will be located in Samoa and USD$250 million per year will be made available for projects in energy efficiency, renewable energies, and sustainable transportation.

World Bank:

Through their Global Facility for Disaster Reduction and Recovery; Pilot Programme for Climate Resilience, $30 million to $60 million will be made available for the Pacific countries with 50% grant and 50% loan[13].

5. OCEANIAN RENEWABLE ENERGY RESOURCES

The Pacific Islands have been identified with the potential for solar photovoltaic and small scale wind power plants. This is particularly true for off-grid applications as many islanders rely on diesel generators at present.

For most islands, passive solar water heating is an applicable renewable technology. There is also a need to integrate renewable energy technologies with existing diesel generator sets for hybrid operation. This includes the use of biodiesel blends, biomass energy and co-generation for stationary power and transport as well as co-generation for industrial applications.

Geothermal energy is limited to Papua New Guinea at present but viable in Fiji, Solomon Islands and Vanuatu. Wave energy is only potentially viable in New Caledonia, Vanuatu and Fiji[14]. All renewable energy sources are viable in New Zealand and Australia[15].

Scientific research indicates that the health of the Pacific Ocean will decline dramatically due to the key threats of pollution, habitat destruction, overfishing, mineral exploitation and climate change.

13 ABD (2009) Climate Change Implementation Plan for the Pacific (2009-2015), http://www.adb.org/Documents/Books/Climate-Change-Implementation-Plan/ccip.pdf#page=14

14 www.aquamarinepower.com- Oceania Resource Map

15 ABD (2009) Climate Change Implementation Plan for the Pacific (2009-2015), http://www.adb.org/Documents/Books/Climate-Change-Implementation-Plan/ccip.pdf#page=14

The future impact on the Pacific Ocean's resources, ecosystems and community livelihoods will be devastating if these threats continue unabated. The International Union for Conservation of Nature (Oceania IUCN) is convening the Pacific Ocean 2020 Challenge in partnership with Pacific Ocean countries in order to address these issues and assure long term sustainability. All Pacific Island countries have developed national energy policies and are working on investment plans for renewable energy development, as well as working on energy efficiency and management to lower their dependence on fossil fuels.

The Government of Tonga has ambitious plans, committing to a target of 50% electrical generation from renewable energy sources by 2012. IUCN is currently sponsoring wind monitoring projects in Vanuatu, mini-hydro projects on Maewo Island and rehabilitation of solar photovoltaic (PV) systems on Santo and Malekula Islands (Vanuatu) and Tonga. These projects should be finalised by 2011 at a cost of USD$1.2 million and potential savings of 118 tonnes of CO_2 annually. Tuvalu plans to install PV systems that feed into the existing grid diesel system and solar street lights on its outer islands. The project will be managed by the Tuvalu Electricity Corporation (TEC) at a cost of USD$800,000. IUCN is also helping to develop the Pacific Centre for Environmental Governance (PCEG), a virtual centre of excellence in environmental governance and policy across the Pacific Islands[16]. There are also numerous other small-scale renewable projects for schools and hospitals with a range of international sponsors and NGOs helping to implement them.

5.1 Renewable Legislation

A co-ordinated framework on climate change in Oceania is communicated through the Pacific Climate Change Roundtable (PCCR) and the Secretariat of the Pacific Regional Environment Programme (SPREP) to keep stakeholders communicating and adhering to *the Pacific Islands Framework for Action on Climate Change, Climate Variability and Sea Level Rise 2000–2004 and The Pacific Islands Framework for Action on Climate Change (2006–2015).* From these frameworks the *Action Plan for the Implementation of the Framework for Action on Climate Change* has been developed in order to tackle a wide range of climate issues. They recognise that across the board, planning, implementation and improved regulations are required not only to mitigate the effects of climate change but also to ensure economic stability - the two are intrinsically linked.

These intrinsic links include: environmental sustainability, energy efficiency, energy and water security, poverty reduction, integrated development, infrastructural improvement, health improvements, urban development, skill building and economic empowerment. *The Pacific Islands Energy Policy and Plan* (PIEPP) developed by the Energy Working Group of the Council of Regional Organisations in the Pacific (CROP) aims to coordinate the energy programmes activity however, none of these plans enforce specific routes to achieve project developments.

16 http://cmsdata.iucn.org/downloads/iucn_oceania_mid_term_document_2009.pdf, IUCN Oceania (2009) Update onthe Regional Programme 2009

The aging energy generation equipment and supply sectors will benefit from this plan in terms of better management but national implementation programmes remain a challenge. Short-term opportunities for demand-side management are being actively considered. In the near term, efficiency and conservation opportunities will normally be considered as the highest priority. Potential longer-term actions could include a broad spectrum of renewable projects. There is strong political support for renewables but private sector development, infrastructure development, and good governance will be required if these technologies are to be implemented across the region at active project level[17].

6. OCEANIAN DESALINATION

Climate change, growing population and scarcity of water resources in the Pacific Islands have led to the increase in adoption of desalination devices for specific buildings such as hospitals and hotel resorts. Public desalination plant are yet to be common place, and desalination has generally developed on an ad-hoc basis across the region.

The islands of Kiribat (pop. ~100,000) have been operating desalination plant since 1999 as a response to the 1998-2000 droughts. A 110m^3/day capacity plant was installed on Betio Island and financed by the government of Kiribati. Two other plant (50-m^3/day capacity) were donated by China and installed in a hospital and hotel to help alleviate water shortage problems on the island. Kiribati has found these plant simple to operate and view direct seawater desalination as a preferred option over lagoons that require biocide treatments.

They would like to strengthen their water mix by using the more cost competitive groundwater resource. Stand alone boreholes are common across these islands; however desalination is still a viable option provided the funding and skills are available for implementation. It is interesting to note that since the desalination plant was installed on Betio Island, the number of diarrhoea cases has dropped from 10,810 in 1992 to 1,684 in the year 2000[18].

6.1 Desalination Projects

Conventional power desalination providers in the Pacific Islands are usually based in Australia and Japan, these include: Veolia Water Solutions & Technologies, who provide treatment applications for brackish water, seawater and wastewater. Their activities in the Pacific Islands include: two brackish water reverse osmosis desalination units for the Nauru Hospital Desalination Plant, an upgrade of the Brampton Island Sewage Treatment plant and water treatment for the Goro Nickel Water Mine

17 ABD (2009) Climate Change Implementation Plan for the Pacific (2009-2015), http://www.adb.org/Documents/Books/Climate-Change-Implementation-Plan/ccip.pdf#page=14

18 Metutera, T (2002) Water Resource Management in Kiribati with Special Emphasis on Groundwater Development Using Inflitration Galleries, www.pacificwater.org,

Water Treatment Plant, New Caledonia. Thus far conventional energy has been the main source of power for these plants[19].

Ace Water Treatment Co., Tokyo, manufactures a range of brackish water and seawater desalination devices. They provide large scale systems that can produce 250 - 2,000 m^3/day (with an energy demand of 4.5 kWh/m^3) and an easy-to-operate Water Buoy series for small scale projects that can produce 65- 220 m^3/day. The Water Buoy series is being installed in Fiji at Vatulele Island Resort hotel.

A serious drought occurred in the Marshall Islands and Ace Water Treatment Co. responded to a special request form the Japanese embassy by providing a unit capable of producing approximately 50 m^3/day of fresh water. They have also supplied units to Tuvalu and Kiribati on the request of their waterworks departments[20]. Oceania Water Treatment, Australia, supplies desalination devices to four different luxury resorts in the Pacific Islands[21].

6.2 The Renewable Desalination Sector

The Pacific Islands also have renewable desalination plant such as Nukubati Island resort, a one-island resort off the north coast of Vanua Levu in Fiji. Nukubati derives all of its energy and water needs from a solar power plant, and showing commitment to full sustainability they also recycle all operational waste[22].

Citor, an Australian reverse-osmosis desalination unit manufacturer for brackish and sea water applications, has partnered with Solar Power Indonesia to provide customised solar desalination units[23]. They provide island packages with units that range from 5m^3 /day (3.1 kW power including pump feed) to 240m^3 (100 kW power including pump feed). Citor have supplied customised systems with and without solar power applications to every state in Australia and have already exported to Indonesia, Singapore, New Zealand, Fiji, Middle East, Malaysia, Papua New Guinea, Brunei, Africa, Mauritius, India, Pakistan, Bangladesh, Myanmar, Philippines, Afghanistan and Iraq[24].

Nauru has an excellent but unexploited solar resource of 5.8 kWh/m^2 per day. A study on the potential for solar desalination is being conducted by SPREP, as part of the Pacific Islands Greenhouse Gas Abatement through Renewable Energy Project (PIGGAREP). An investigation of

19 http://www.veoliawaterst.com.au
20 http://www.acewater.co.jp
21 http://www.oceaniawatertreatment.com.au/project4.htm
22 http://www.nukubatifiji.com
23 www.solarpowerindonesia.com
24 http://www.citor.com.au

wind power feasibility in the highest areas of Nauru was undertaken by WINERGY of New Caledonia in 2006 and it was estimated that wind power could provide 25% of the Island's electricity demand[25].

The Vanuatu Renewable Energy Power Association (VANREPA) was established to promote renewables on the island and has been successfully implementing some small scale solar and wind projects in schools with help from the European Union Education Infrastructure Project (EDUTRAIN). VANREPA is also considering solar desalination a viable source of clean water[26].

Over 80% of the Vanuatu population have no access to improved water and sanitation. Currently all water treatment plants are owned by the hotel resorts. Most residents rely on ground and surface water, however, the Vanuatu National Adaption Programme does include plans for desalination and renewable developments as do many other island state strategies[27]

Across the Pacific region, successful implementation of desalination and renewables into the energy and water mix will require institutional backing in the form of policy, finance and technological support[28]. There are opportunities for small scale demonstration projects funded by international aid and finance mechanisms. Each island nation will require a separate approach and assessment in order to most efficiently identify project opportunities.

7. COUNTRY PROFILE: AUSTRALIA

Australia is a vast island continent with a population of 22 million of which most live in urban areas along the country's 36,735 km coastline. The climate is temperate with inland desserts and snow covered mountains. The Commonwealth Government, also known as the Australian Government or the Federal Government, regulate national policy.

The Commonwealth of Australia is divided into six states which possess the power to develop policy not contained under Section 51 of the Constitution. Territories are areas within Australia's borders that are not claimed by one of the six states. Territories can be administered by the Commonwealth Government, or they can be granted a right of self-governance. Local governments are established by state and territory governments to take responsibility for public services. The Australian economy is a developed market economy with GDP at approximately £1 trillion (2008) which places it as the 14th largest economy in the world. The service sector dominates the economy representing 68% of the GDP, followed by the agricultural and mining sectors at 10%. The latter sectors account for more than half of the country's exports. Australia has been developing desalination and renewable energy

25 SPREP (2009) Pacific Islands Greenhouse Gas Abatement through Renewable Energy Project (PIGGAREP) - Nauru Interventions http://www.sprep.org/climate_change/pignauru.htm

26 http://vanrepa.org/project.htm

27 SPREP (2008) The Rebulic of Vanatutu National Adaption Programme, http://www.sprep.org

28 SPREP (2008) Pacific Adapation to climate change: Tuvalu Report of In-Country Consultations, http://www.sprep.org

capacity at a rapid pace. It also provides aid to assist Pacific Island nations in coping with climate change through sustainable development[29].

7.1 Australia: Energy Sector

About 85% of the electricity generation in Australia is from large coal-fired power stations, gas plants contribute about 7% and hydro schemes about 7%. Australia has high green house gas emissions due to its reliance on coal[30]. GDP contribution from the electricity sector was AUD$14.64 billion or 1.3% of total GDP (2008-9), the natural gas sector contributed AUD$1.55 billion and in total these sectors employ 52,000 people.

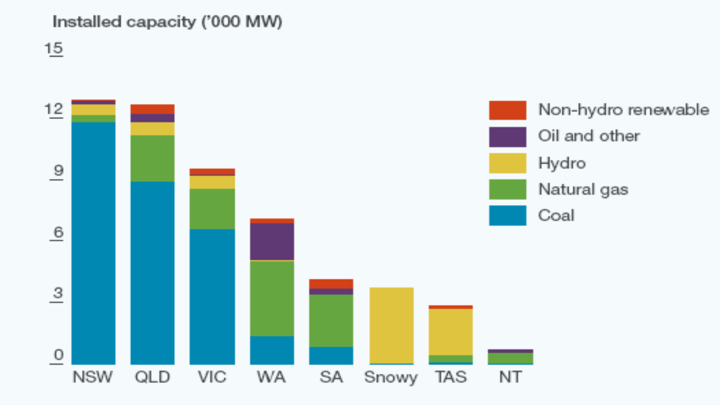
Conventional energy is still receiving significant investment, examples include: Origin Energy's AUD$1 billion natural gas power plant in Western Victoria and an AUD$780 million gas fired power plant in Queensland both of which will be completed this year. HRL is spending AUD$790 million on low-emission coal fired power plant in Victoria due to be completed in 2012. However, large renewable energy projects are in the pipeline; like Epuron's proposed AUD$2.2 billion wind farm near Brokenhill, NSW and the reconditioning of the Lake Bonney wind farms in South Australia[31].

Australia has a tremendous renewable resource, and at this time, renewable generation accounts for 8% of the electricity supply which has created 15,000 jobs (2006) according to the Renewable Energy Generators of Australia Ltd (REGA)[32]. The power sector generation (2008-09) in Australia varies from state to state as shown in the figure below:

Figure 1: Electricity Installed capacity (MW) 2008

Consumption by sector

- Residential: 27.8%
- Commercial: 22.6%
- Metals: 18.2%
- Aluminium smelting: 11.2%
- Mining: 9.3%
- Manufacturing: 9.1%
- Transport and storage: 1.0%
- Agriculture: 0.8%[33]



Source: esaa, company annual reports, NEMMCO, Clean Energy Council

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29 http://australia.gov.au/about-australia/our-government

30 Knights, D., MacGill, I & Passey, R. (2006) The sustainability of desalination plant in Australia: is renewable energy the answer? http://www.ceem.unsw.edu.au/content/userDocs/OzWaterpaperIMRP_000.pdf

31 Access Economics (March 2009) Investment Monitor 2009, www.AccessEconomics.com.au

32 REGA (Aug 2006) Renewable Energy Generators Australia 2 Submission to Geosequestration Inquiry, www.aph.gov.au/

33 ESAA (2009) The Energy Industry in Australia: Facts in Brief, www.essaa.com.au

The *Renewable Energy Map of Australia* (www.ga.gov.au/renewable) provides information about renewable energy power sources in Australia and power stations which can be clicked on to access information on the operator and capacity - this is an extremely useful source.

The current status of renewable energy projects is displayed below:

Technology	Operation	Proposed
Solar	54	35
Hydro	110	39
Ocean Energy	3	8
Wind	58	57
Biomass	149	48

Table 1: Proposed and operational renewable energy projects.

Australia has a well established solar industry and exports flat bed panels for solar heating to other nations. Applications in Australia include off-grid schemes for isolated communities and grid connected systems for city buildings. Future large PV arrays are likely to bring down the cost of this technology.

Wind power is an established, rapidly expanding industry which is well supported with government incentives. Wind power has already been used to power desalination plants in coastal areas around Australia, although the link between the wind power and desalination is indirect with buffering through the electrical grid.

Australia is home to one of the few ocean power developers with desalination technology; Oceanlinx Pty who has projects in Tasmania however, the challenge of connecting coastal applications to the grid is a barrier that must be overcome[34].

7.2 Australia: Grid Infrastructure

Australia is a massive continent and as a result the electricity network is not fully interconnected. The National Electricity Market (NEM) is composed of eastern and southern Australia, covering five state-based transmission networks (New South Wales, the Australian Capital Territory, Victoria, South Australia and Tasmania). These states possess 13 distribution networks and 260 registered generators who sell electricity to the NEM wholesale pool. The NEM pool is regulated for legal

34 ESAA (2009) Electricity generation technologies, www.esaa.com.au

compliance by the Australian Energy Regulator (AER) and the Australian Energy Market Operator (AEMO).

Western Australia has a stand-alone market called the Wholesale Electricity Market (WEM) which operates via the South-West Interconnected System (SWIS) and is administered by the Independent Market Operator (IMO). The system is regulated by the Economic Regulation Authority (ERA) under the *Electricity Industry Act 2004*, the *Electricity Industry (Wholesale Electricity Market) Regulations 2004.* The Western Market allows for provisions of separate capacity mechanisms and unlike the National Electricity Market (NEM), a net pool rather than gross pool arrangement is administered. In a net pool all of the electricity is traded through a central pool and settled by the central market operator, whilst in a gross pool a variety of bilateral instruments typically are used.

The Northern Territory has a small remote population made up of Independent Power Producers (IPPs), remote generators and off-grid capacity. They have introduced reforms but at present there is no open competition in generation or supply. In Australia, total installed electricity grid connected capacity is 48, 541MW and a further 4,810 MW is composed of non-grid capacity[35].

The Australian Government is providing AUD$100 million to develop a *Smart Grid, Smart City* demonstration project. This will use smart grid technology to improve monitoring and connections to communication and other energy use networks. They believe Smart Grids will aid the integration of renewable energies into the transmission networks particularly aid small scale renewable projects ability to feed back to the grid[36].

7.3 Australia: Renewable Legislation

In December 2007, the Council of Australian Governments (COAG) agreed to bring state-based renewable targets into a national, expanded Renewable Energy Target Scheme by 2009. After various consultations they agreed on the Expanded Renewable Energy Target allowing the creation of ‘Solar Credits’ for small scale solar, wind and hydro projects.

The Australian Government has set a target of 20% electricity generation from renewable energy by 2020. An additional 45,000 GWh/year of renewable energy will be required to meet this target. Key legislation includes the *Renewable Energy (Electricity) Amendment bill 2009* and the Renewable *Energy (Electricity-charge) Amendment bill 2009.* Both these bills were passed to encourage renewable development, energy efficiency, bolster the economy, skills sector and improve regulating systems across the country.

Australia signed-up to the Kyoto Protocol and has set a target of cutting its greenhouse gas emissions by 60% from 2000 to 2050. At Copenhagen they agreed to meet targets on the stipulation

35 ESAA (Oct 2009) Energy Supply Association of Australia: Australia’s Electricty Markets, www.esaa.com.au

36 Environment. Gov (Sep 2009) Smart Grid, Smart City: Facts about the National Energy Efficiency Initative, http://www.environment.gov.au/sustainability/publications/index.html#renewable

that the entire world played their part. They have also implemented large research programmes to improve their scientific understanding of climate change[37].

The Renewable Generators Association (RGA) believes that renewable energy is a more cost effective solution in the long term compared to conventional energy sources. This option contributes towards the country's climate change target while also improving energy security by diversifying the mix. RGA has encouraged the government to consider full life-cycle costs of conventional plant in comparison to renewables in order to justify stronger incentive regimes for renewable energy. It is recognised that government support for renewable technology has assisted the industry, but further regulatory and financial support is necessary[38].

7.4 Australia: Water Sector

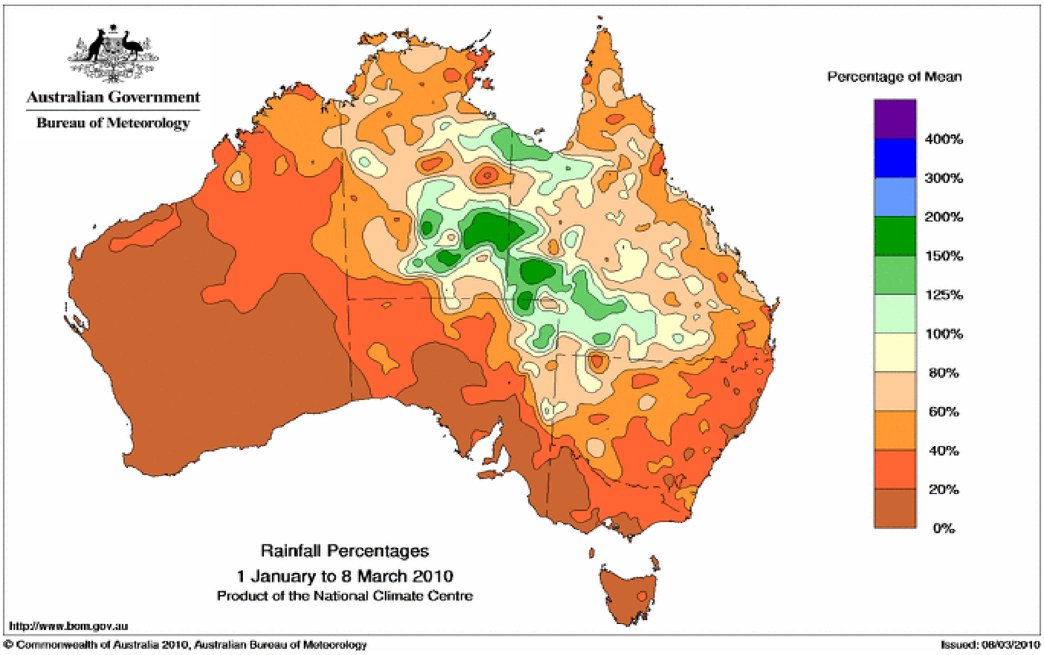
The Australian water sector is composed of separate state water markets with their own administration and specific water management systems that suit their resource. The states trade water with each other in the form of 'entitlements' or water rights to access, this involves a system of small-scale traders to large inter-traders based around the Murray-Darling Basin. The states surrounding the basin generally have the largest water resource and include: Queensland, New South Wales, the Australian Capital Victoria and South Australia.

New South Wales, Victoria and Queensland trade the largest volumes of water. This water market is quite lucrative with a total sale of water allocation at AUD$606 million in 2008-09, with the states around the Murray-Darling Basin creating half of that amount. Currently, the average price has been $2/m^3 [39]. The Map below gives an indication of where water resources are limited.

37 ESSA (2009) Australia's Renewable Energy Target, http://www.climatechange.gov.au/

38 REGA (Aug 2006) Renewable Energy Generators Australia 2 Submission to Geosequestration Inquiry, www.aph.gov.au/

39 NWC (2008) Australian Water Markets Report 2008-2009, http://www.nwc.gov.au/resources/documents/AWMR0809_Foreword_and_explan_notes.pdf



Map 2: Rainfall Percentages Jan-Mar 2010.

7.5 Australia: Access to Water

Australia is a dry continent, in which sourcing water was historically one of the key skills of the native aboriginal people. Droughts are common and rainfall varies from 2000mm in coastal areas to only 200mm a year inland. 90% of this rainfall is not available due to plant life absorption and evaporation. 10% of rainfall runs into rivers and groundwater sources, mainly located in the Gulf of Carpentaria, Timor Sea and The North East Coast. The Murray-Darling basin does not benefit from this run-off and is relatively dry; however, this 10% provides more than half of Australia's water needs.

There are 501 large dams in Australia. In 2004-05 the total dam storage capacity was 83,853 million cubic metres. There are also more than two million farm dams across Australia with an estimated 8000 million cubic metre capacity. Groundwater contributes 17% to the total water resource. Ground water is collected in the Great Artesian Basin which is the largest ground water reserve in the world covering 22% of Australia's water needs[40]. Around 75% of water used is returned to the environment and the remainder is mostly used by agriculture, households, water suppliers and other industries. Based on 2004/05 data, sector use is broken down as follows:

40 National Water Commision (2008/09) Water Availabilty in Australia, http://www.nwc.gov.au/www/html/234-water-availability-in-australia.asp?intSiteID=1

- Agriculture: 65% (12,191 million cubic metres/year)
- Household: 11% (2,108 million cubic metres/year)
- Water supply industry: 11% (2083 million cubic metres/year)
- Other industries (including electricity and gas): 7.4% (1,330 million cubic metres/year)
- Manufacturing: 3% (589 million cubic metres)
- Mining: 2% (413 million cubic metres/year)

The Water Services Association of Australia (WSAA) imposes water restrictions across the country on a monthly basis. Large, city water reserves have declined; for example, last year the water storage capacity of Sydney and Canberra was only half full. Many smaller towns live under regular water restrictions such as no garden sprinklers, as well as water efficacy initiatives such as water recycling and efficient agriculture practice.

Australia has managed to reduce their water use by 14% from 2000-2005 with the help of these restrictions. However, the mining sector has grown, and in the same period, their water use increased by 29%[41]. All regional governments have recognised that planning and regulation needs to be strengthened to address current groundwater use in farms (dams and bores), large-scale forestry plantations as well as intercepting and storing of overland flows - which are being accessed without official water access entitlements[42].

7.6 Australia: Water Legislation and Policy

Australia faces major water resource management challenges due to increasing populations, particularly in the urban environment, limited surface water and drought. The Australian government aims to improve pricing, continue to place water restrictions, promote water use efficacy and develop new technologies. In addition, they aim to reduce demand by recycling of effluent, improving rainwater and storm water storage and installing desalination plants.

The department for Climate Change and Water, headed by Senator Penny Wong, is the national body for the water sector. Research into resource management is part of the Department for Innovation and Research's remit[43]. *The Water Reform Framework 1994* initiated a series of reforms and inter-regional communication on water resources. As a result, much progress on water management and ownership has been made in each state and territory over the past ten years.

Following on from this, *The National Water Initiative 2004* was signed by the Council of Australian Governments (COAG). The main aims are to improve water management and establish a solid

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41 National Water Commision (2008/09) Water restrictions and Storage Reports, http://www.nwc.gov.au/www/html/234-water-availability-in-australia.asp?intSiteID=1

42 NWC (2009) Intergovernmental Agreement on a National Water Initiative, http://www.nwc.gov.au/resources/documents/Intergovernmental-Agreement-on-a-national-water initiative.pdf

43 NWC (2009) National Groundwater Assessment Initiative, http://www.nwc.gov.au/www/html/177-national-groundwater-assessment-initiative.asp

research base, monitor the performance of water providers, invest in improving water infrastructure, and in particular, strengthen planning and regulation to ensure proper legal water access.

The *Water Act 2007* established a Commonwealth Environmental Water Holder and gave the Bureau of Meteorology new water information functions[44]. *The Intergovernmental Agreement on Murray-Darling Basin Reform 2008* amends *The Water Act 2007* to include an independent Murray-Darling Basin Authority and to strengthen the regulatory role of the Australian Competition and Consumer Commission (ACCC).

The National Water Commission (NWC) will audit the effectiveness of the Murray-Darling Basin Plan and monitor resources within the basin[45]. The COAG Working Group on Climate Change and Water is focussing on enhancing regulation over allocation of water, urban water reforms and improving the skill and information base for the water sector. The latest piece of legislation is *Water for the Future 2009* which plans to address climate change, secure water supply, use and quality. The AUD $50 million National Groundwater Assessment Initiative has also been developed as part of the Groundwater Action Plan to fully investigate the resource in order to manage it sustainably and review the potential for saline and brackish water sources[46].

7.7 Australia: Government

The Howard government made the first steps to encouraging renewables by allocating AUD$300 million in funding for renewable energy programmes from 1997-200347. The Renewable Energy (Electricity) Act 2000 created Renewable Energy Certificates (RECs) as a form of currency to encourage renewable targets. Various renewable generation projects are awarded RECs via the Office of the Renewable Energy Regulator, qualifying technologies include: solar PV, wind and hydro.

The Renewable Power Percentages (RPPs) were also introduced as a rate of liability for wholesale electricity purchase. For example, in 2009 the RPP was 3.64%. A liable party purchasing 100,000 MWh of electricity in 2009 must surrender 3,640 RECs to fully discharge their liability for this year48. The RECP commercial programme has provided funding of between AUD$100,000 and AUD$1 million to numerous renewable projects including solar, wind and wave49. The Australian

44 NWC (2009) National Water Initiatives, http://www.nwc.gov.au/www/html/20-other-water-initiatives.asp

45 NWC (2009) Intergovernmental Agreement on a National Water Initiative, http://www.nwc.gov.au/resources/documents/Intergovernmental-Agreement-on-a-national-water initiative.pdf

46 NWC (2009) National Groundwater Assessment Initiative, http://www.nwc.gov.au/www/html/177-national-groundwater-assessment-initiative.asp

47 Environment.Gov (2003) Renewable Energy Commercialisation in Australia, http://www.environment.gov.au/archive/settlements/renewable/recp/index.html

48 OREG (April 2001)Australia leads world with national renewable energy market, www.greenhouse.gov.au/markets/2percent_ren.

49 Environment.Gov (2009) Renewable Energy Commercialisation Programme (RECP), http://www.environment.gov.au/settlements/renewable/recp/projects.html

government is also very supportive of renewable energy and climate change research and development, the department for Climate Change and Water is providing AUD$31.2 million in funding over the next four years to the Super Science Initiative: Marine and Climate50.

The Minister for Climate Change and Water, Senator Penny Wong, and the Minister for Innovation and Research, Senator Kim Carr, have announced a new AUD$60 million National Centre for Groundwater Research and Training to be led by Flinders University as part of the National Groundwater Initiative. This funding adds on to The National Water Initiative 2004, which has received AUD$30 million in government funding from the Australian Research Council and National Water Commission. Another 20 organisations are involved in adding to water resource and management research by contributing a further AUD$30 million over the next five years. The government will also be investing AUD$12.9 billion over the next ten years to implement the Water for the Future 2009 Plan51.

The Rudd government introduced the Renewable Energy Target. The Enhanced Renewable Energy Target Scheme 2009 has further developed incentives for both industry and households to meet the country's renewable targets and encourage the job market. Once this is achieved, it will be phased out from 2020-2030.

This policy is separated into two parts:

The Small-scale Renewable Energy Scheme (SRES) will cover small renewable projects such as solar photovoltaics with a fixed price of AUD$40 per MWh of electricity produced for households.

The Large-Scale Renewable Energy Target (LRET) will provide subsidies for large scale renewable projects like wind farms. The government is currently in consultation with the renewables industry, states and territories to work out the specifics of a state-wide LRET mechanism[52]. The Office of the Renewable Energy Regulator oversees the implementation of the existing Mandatory Renewable Energy Target scheme and will also administer the expanded national RET scheme once it comes into operation[53].

Each state has provided their own Renewable Energy Feed in Tariffs (FITs) which are largely aimed at small scale projects such as solar panels for households. Some states such as the Australian Capital Territory and New South Wales have made strong commitments to encouraging renewables; other states have made more timid commitments based on excess of small scale PV solar projects. As shown below:

50 Climate Change (May 2009) Climate Change science: the foundation of our policy response, http://www.climatechange.gov.au/minister/wong/2009/media-releases/May/Budget%202009-10/budmr20090512b.aspx

51 NWC (2009) National Groundwater Assessment Initiative, http://www.nwc.gov.au/www/html/177-national-groundwater-assessment-initiative.asp

52 Climate Change dept (Feb 2010) Enhanced Renewable Energy Target Scheme, http://www.climatechange.gov.au/en/minister/wong/2010/media-releases/February/mr20100226.aspx

53 www.orer.gov.au.

State Renewable Energy Feed In-Tariffs

New South Wales: the largest FIT, at a value of AUD$0.60/kWh for seven years on small-scale renewables.
South Australia: a smaller FIT mechanism of AUD$0.44/kWh for any excess generation from domestic electricity customers for a period of 20 years for PV solar.
Queensland: has the same FIT as South Australia

Victoria: has a FIT of AUD$0.60/kWh for excess generation over a period of 15 years for PV system less than 2 kW in size.

Australian Capital Territory: this is a state that is paying for gross generation rather than just 'excess' for all small-scale renewables and not just solar PV. The price offered is AUD $0.57/kWh for systems less than 10 kW in size. The tariff for systems 10 kW to 30 kW is 80% of the retail rate, and for systems greater than 30 kW the tariff is 75% of the retail rate. These prices are guaranteed for a period of 20 years from the date of installation.

7.8 Australia: Private Investment

The renewable energy industry is already making a significant contribution to the national economy. Research conducted by REGA in 2006 found that the industry provides 15,000 jobs both directly and indirectly with annual sales of AUD$2 billion and an estimated AUD$8 billion in invested assets. Total investment in the renewable sector is estimated at AUD $257 million per annum with approximately AUD$398 million invested over 2006-2009 period from both private and public funds[54]. Energy projects are a high priority in order to secure capacity demand which is evident by the AUD$2 billion spent on new coal and gas plant in Victoria and Queensland. In addition, Epuron has also proposed a AUD$2.2 billion wind farm near Brokenhill, NSW[55].

At a cost of AUD$22 billion, it is estimated that Australia requires a further 11,000MW of additional capacity from renewables in order to meet its 2020 renewable energy obligations[56]. The Australian government has attempted to boost their clean technology market with a Carbon Pollutant scheme to encourage the carbon trading market in Australia[57]. The country has lagged behind other similar markets due to a financial sector that has a predominant knowledge and investment base in conventional energy. However, they are well connected to Asian markets and the new aggressive and substantial government investments in clean technology projects should encourage investors[58].

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54 REGA (Aug 2006) Renewable Energy Generators Australia 2 Submission to Geosequestration Inquiry, www.aph.gov.au/
55 Access Economics (March 2009) Investment Monitor 2009, www.AccessEconomics.com.au
56 Walter, L & Macfee, N (Aug 2009) Green Business FACTBOX - Australia's renewable energy sectorhttp://www.reuters.com/article/idUSTRE57J0M120090820
57 AusTrade (2010) Clean Energy Carbon Tradinghttp://www.austrade.gov.au/Invest/Opportunities-by-Sector/Clean-Energy/Carbon-Trading/default.aspx
58 http://www.cleantechventures.com.au/funds-under-management/cleantech-australia-fund/. Harrison, S (Dec 2009) Outlook for Cleantech Investment in 2010, http://www.financierworldwide.com/article.php?id=5514

Currently, Cleantech Ventures, an Australian venture capital company is managing an AUD$80 million portfolio funded by the government and it hopes to encourage further investment in the sector.

7.9 Australia: Desalination

Australia has recently pursued desalination techniques to supply potable water from ocean and brackish ground water in dry, remote areas. The plant installed range from multistage flash distillation, vapour compression distillation, electrodialysis and reverse osmosis (RO). Today RO is the predominant form of desalination plant. Climate change and water security has generated resurgence in seawater desalination plant in the past ten years.

Currently, 49 large desalination plants are in operation, producing a total of 294,000 m^3/day which requires 722 MWh/day in power. Future plants, providing a further 976,000 m^3/day, are under construction and proposed plant will produce an additional 925,000 m^3/day. At present most desalination plant are in Western Australia. The majority of proposed plant will supply large scale desalinated seawater to major cities across the entire nation by 2013.

At present 86% of desalination plant use seawater, 1.2% use brackish water and 12% use effluent. Recovery of potable water from seawater is about 20-42% and much higher for brackish waters. Brine water waste is usually returned via ocean outfall mechanisms. Potable water from desalination costs approximately AUD$1.25/$m^3$.

Energy requirements for seawater desalination are higher than brackish water applications because more RO pressure is required for the process. The average energy consumption is 3-3.7 kWh/m^3 for seawater sites compared to 0.7-1 kWh/m^3 for brackish water sites and 1.2 kWh/m^3 for industrial effluent. The use of desalinated water for both potable and industrial applications is expected to rise from 0.57% (2008) to 4.3% in 2013. Renewable applications such as solar, wind and wave could assist in providing sustainable power sources for this growing water industry[59].

Desalination plants have been increasingly proposed for urban centres and rural communities in order to meet the growing water demand. This is due to the fact that desalination mitigates the reliance on rainfall, and the cost of a RO seawater plant has dropped by 300% in the past 15 years. Desalination is an energy intensive activity and therefore plans to power more plant with renewables are currently being studied.

Large desalination plant are likely to be connected to the state electricity grids. Problems with powering desalination plant include: securing the infrastructure to deal with peaks in demand, overcoming the national high reliance on coal to implement more renewable energy capacity and

59 Hoang,M., Bolto. B et al (Feb 2009) Desalination in Australia: National Research Flagships, Water For a Healthy Country, www.csiro.au

regulating desalination plant that claim renewable credentials when in reality they are connected to a predominantly coal powered grid system.

7.10 Australia: Renewable Desalination Projects

In 2007, the Royal Melbourne Institute of Technology (RMIT) developed a solar thermal desalination research project operated by the Energy Conservation and Renewable Energy Group at RMIT to explore the use of saline land. They conducted a field demonstration at Pyaramid Salt Pty (a salt manufacturer) to demonstrate the potential of harnessing solar thermal energy for the desalination of seawater via multi-stage flash (MSF) solar technology and multi-effect solar evaporation (MEE) technology. This concept preheats saline water before it falls into a fine spray on heated tubes. Some water evaporates, which is used to heat tubes prior condensing and collection of the potable water.

This process could produce salt and fresh water efficiently and supply between 10,000-25,000 m^3 of fresh water a day[60]. The College of Engineering and Built Environment at Central Queensland University presented a design in 2008 for a solar photovoltaic powered, small-scale desalination system for use in remote off-grid communities[61].

There are a number of renewable desalination projects in Oceania; below are three examples of renewable desalination projects in Australia:

60 RMIT News (Jan 2007) Fresh water and Salt on the table, http://rmit.com.au/browse;ID=a6mw5qwzkhwk

61 Schrader, J. & Rasul, M. (2008) Design and Simulation of a small scale solar powered desalination system, Energy and Environmental Engineering Series, Proceddings of the 3rd IASME/ WSEAS Intenational conference onf Energy & Environment, pp. 457-463,

The Kwinana Desalination Plant	
Location	South of Perth, on Indian Ocean, Industrial Park, several acres
Partners	The plant was built by Degremont of France, the Perth Water Corporation, Western Australia Water Corp. (plant developer) and West Australian Government (client).
Value	Construction of the plant: AUD $387 Million Annual operating costs: $20million
Funding	N/A
Technology	Reverse-Osmosis technology. The water is sucked through a 200m pipe with the inlet positioned offshore in Cockburn Sound, at a rate of 0.1 cubic meters per second. It takes half an hour to process and distribute the desalted water[62].
Power	Emu Downs Wind Farm has 48 turbines (80MW), located at Cervantes, a three hour drive north of Perth. Power is fed into Western Power's grid and provides enough renewable energy to power the desalination plant. The plant requires 26MW to run and uses an estimated 4.1 kWh/m^3 of water produced[63].
Status	The Plant opened April 2007 and was the first of its kind in Australia. Perth has experienced a 21% decline in rainfall over the past 10 years, so this plant has helped supply potable and industrial water to the area. Both Western Power and the Western Australia Water Corp. use the plant and the power from the wind farm to contribute to the REC scheme. The Plant added an average of £45/per year onto the average household water bill. Kwinana has produced more than 100 billion litres of water since its commissioning in early 2007[64].

62 Hunter, N. (Sep 2009) Tackling drought in an arid climate, http://www.workingwithwater.net/view/3982/tackling-drought-in-an-arid-climate/

63 Knights, D., MacGill, I & Passey, R. (2006) The sustainability of desalination plant in Australia: is renewable energy the answer? http://www.ceem.unsw.edu.au/content/userDocs/OzWaterpaperIMRP_000.pdf

64 Sullivan, M. (June 2007) The Kwinana Desalination Plant, http://www.npr.org/templates/story/story.php?storyId=11134967

Aquasol Plant: Port Augusta municipal-scale solar desalination plant (proposed)	
Location	Point Paterson, 12 Km off Port Augusta, on the Eastern side of the Upper Spencer Gulf, South Australia
Partners	Aquasol Infrastructure Ltd (project developer), MAN Solar Millennium (solar developer), Hatch (D&C, Project Management, Engineers Civil, Structural & Marine)[65].
Value	AUD $650 million
Funding	Aquasol initially received funding from Australian Greenhouse Office's Advanced Energy Storage Technology program (no longer running). They have not managed to secure the required funding from the federal government to continue at present.
Technology	*Multi-Effect Distillation;* evaporates salt water using a vacuum and re-condenses the vapour into drinking water. The plant is configured so that reverse osmosis could be added in the future.
Power	2.7-4.5 kWh/m^3. Aquasol's facility will feature a 1.75-kilometer square mirror field. The desalination plant proposed to use solar thermal storage, gas turbines and other operating equipment to create a synergy of technology for this plant[66].
Status	The project has been at the planning stage for several years. The plant is on hold. The company offered to provide 2 million m^3 of free water to Port Augusta every two years as a sweetener, but despite the council's support for the project, it has not received the necessary government funding[67]. Aquasol's chief executive officer Michael Fielden said the plant has gained major project status, but is seeking to raise capital, which is difficult in the current economic climate. They hoped to start constructing it next year.

65 http://www.solardesalination.com.au/

66 http://www.solardesalination.com.au/

67 ABC Net (Jan 2007)Aquasol to donate more water to Port Augusta, http://www.abc.net.au/news/stories/2007/01/17/1828429.htm

Port Kembla, NSW, Australia – Operational Pilot Project	
Location	Port Kembla, 400m offshore, at a depth of 9 m.
Partners	Port Kembla Port Corporation, NSW Department of Lands, Wollongong City Council NSW Fisheries, Integral Energy, Australian Greenhouse Office. Technology support from: University of Syndey, University of New South Wales, Queens University Belfast[68].
Value	AUD$650 million
Funding	In 1999, Oceanlinx received a grant worth AUD$750,000 from the Federal Government to develop the Port Kembla project. May 2004, they were awarded an AUD$1.21 million grant by the Australian Federal Government, as part of the Aus-Industry R&D Start Grant Program. The Australian Federal Government will match, dollar for dollar, the company's expenditure on its Wave Energy Optimisation program.
Technology	Oceanlinx Mk3 WEC device for desalination, combined with the provision of power from the grid to balance the energy supply during wave down times. The Oceanlinx unit is capable of producing either clean energy or potable desalinated water, driven by Denniss-Auld turbine technology.
Power	500kW initially, enough to power 500 homes with potential expansion.
Status	Operational - Installed October 2005 (on time). Grid connected via 11kV cable. Project has been successful and is in the process of decommissioning to make way for a pre-commercial project in the same location. They have successfully demonstrated their desalination capability[69].

68 Baddour, E. (Mar 2005) Ocean Energy- An update, http://www.oreg.ca/docs/march_presentations/EmilePresentation.pdf

69 Oceanlinx (June 2007) Inquiry into Developing Australia's non-fossil fuel energy industry, submitted to the Standing Committee on Industry and Resources, http://www.aph.gov.au/house/committee/isr/renewables/submissions/sub28.pdf

7.11 Renewable Desalination Market Potential

Australia sees desalination as an option and is by far the most advanced nation in the Oceania region for desalination plant powered by renewable technology. They have implemented a suite of reforms and regulations for the renewable energy and water sectors underpinned by impressive funding mechanisms for technology, infrastructure and R & D in both these areas. There is still a heavy reliance on coal, however, a number of large scale renewable desalination projects are in operation and more projects under development.

Western Australia's water minster, Graham Jacobs, recently announced an AUD$995 million, 137,000 m³/day desalination plant powered by renewable due to be commissioned in 2011. In addition, go ahead has been granted for a project outside Binningup for a desalination plant led by the Western Water Corporation and Southern Sea Water Alliance, a consortium of Spanish companies: Tecnicas Reunidas and Valoriza Agua as well as Australian companies A J Lucas and Worley Parsons.

A contract for a new AUD$3.5 billion, 150 billion litre desalination plant, in drought-stricken Victoria, is set to become the largest facility of its type in Australia. It will be built by a public-private partnership and led by the consortium, AquaSure (build and operate) which is composed of Degrémont, Suez Environment, Thiess and the Macquarie Capital Group.

AquaSure will build and operate the plant, which is being constructed at Wonthaggi, 132 km south of Melbourne; this will be one of the world's largest public-private partnerships. The plant is expected to generate revenues of USD$1.7 billion over a 30 year period. Investment funds from Australia, the UK and South Korea have also taken equity stakes in the project. The plant will supply one third of Melbourne's water needs.

The Victoria Plant will be powered by 43 wind turbines being built at Glenthompson, Southwest Victoria, and a 183 wind turbine (300MW) farm is planned for Macarther, 270km west of Melbourne[70]. Desalination in Australia is not without its detractors; the Group Against Desalination in Victoria demonstrates against the Victoria plant through online petitions and public meetings. They argue that the environmental marine and visual impact of such plant is unacceptable and other forms of resource, such as the recycling of effluent, should be pursued instead[71]. However, the Australian government recognises the importance of improving the water resource mix. Renewable desalination technology developers should look into developing in Australia because sufficient regulations and financial incentives are present and the country could serve as a spring board into the Pacific island market.

70 Hunter, N. (Sep 2009) Tackling drought in an arid climate, http://www.workingwithwater.net/view/3982/tackling-drought-in-an-arid-climate/

71 http://www.yourwateryoursay.org/action-group/

There is undoubtedly a market in Australia for off-grid desalination systems powered by renewable energy. However, the relatively availability of conventional energy sources means and their low cost means that currently there is little development in this area. In addition, the major focus for renewable energy powered desalination in Australia has been on the larger facilities=. The effect of this is that smaller off-grid systems have received relatively little attention.

South Africa

EXECUTIVE SUMMARY

South Africa is the most developed country in sub-Saharan Africa. However, the political history of the country means that there is a wide range of living standards across the country, which is mirrored in the access to fresh water. Although it is recognised that desalination will have a significant role in providing universal access to fresh water, there is currently less enthusiasm for renewable energy desalination projects due to the perceived high project costs. This is currently exasperated by the very low cost of electricity against which renewable energy projects must compete. In addition, the region suffers from a significant shortage of skilled personnel, at both the technical and managerial levels, which creates challenges for the successful completion of new projects. However, if the political perspective were to change then South Africa has an abundance of renewable energy that could be exploited to power desalination projects.

1. OVERVIEW OF SOUTH AFRICA

South Africa became a political democracy in 1994. The government inherited a country with a two tier system of infrastructure and development. Large divides were found in the economy and few had access to the basic services of electricity, sanitation and water. In fact, some areas still do not have access to clean water and services. With 5.2 million people infected by HIV, malaria and TB continuing to spread, the current population of 48 million is likely to reduce to 35.1 million by 2025 – this is dependent upon future immigration figures.[72]

South Africa has made admirable strides to rectify this situation through black economic empowerment programmes, large investments in infrastructure and fiscal expenditure dedicated to address poverty and sustainable economic development[73]. The South African government has put

72 State of the Environment (Dept of Environmental Affairs and Tourism), Indicators: Access to water, http://soer.deat.gov.za/indicator.aspx?m=451

73 WaterforAfrica (2009) Water and Sanitation Facts, http://www.waterforafrica.org.uk/go/more-information/water-and-sanitation-facts/

out numerous papers and strategy on sustainable growth and development but faltering implementation at a municipal level is a continuing challenge[74].

The country signed up to the Millennium Development Goals (MDGs) in 2002; with a single goal dedicated towards providing 300 million people on the African continent with access to clean water[75].

South Africa's key economic sectors are mining, transport, energy, manufacturing, tourism and agriculture. They are the world's largest producer of platinum, gold and chromium.[76]The government is a constitutional multiparty democracy with local, provincial and national governance. South Africa has an abundant supply of natural resources; its financial markets are well established and the stock exchange is the 10th largest in the world[77]. Currency is the South African Rand (ZAR or R.), with 1.00 EUR equalling 10.09 ZAR (Mar 2010)[78]. In the last ten years there has been significant investment in the water sector but further investment is still required to improve storage capacity, supply services, water management and reduce water pollution[79].

Climate change is not a theory in South Africa, it is reality. The country is already experiencing the effects of higher temperatures, extreme weather conditions and less rainfall; which is predicted to intensify over the next decade.

2. SOUTH AFRICAN ENERGY SECTOR

South Africa relies heavily on coal production which accounts for 93% of the country's power capacity, followed by nuclear at 5% and hydroelectric at 2%. Currently the state owned utility, Eskom (largest utility in the world), is both a power generator and grid system operator. Eskom supplies two thirds of the electricity used in the Southern African Development Community (SADC) region. They have a capacity of 42,000MW and are planning an additional 40,000MW of capacity over the next 20 years to meet projected demand. Eskom recently re-opened three coal power stations, they are currently constructing two new coal fired powered stations, two open-cycle gas turbines and one nuclear plant.

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74 SADC (2009) SA- Country Profile, http://www.sadc.int/ SA Country Profile

75 WaterforAfrica (2009) Water and Sanitation Facts, http://www.waterforafrica.org.uk/go/more-information/water-and-sanitation-facts/

76 State of the Environment (Dept of Environmental Affairs and Tourism), Indicators: Access to water, http://soer.deat.gov.za/indicator.aspx?m=451

77 WaterforAfrica (2009) Water and Sanitation Facts, http://www.waterforafrica.org.uk/go/more-information/water-and-sanitation-facts/

78 http://www.xe.com

79 Samson, M. (2008) Inclusive African Cities: Mapping Chanllengs and Opportunties in Contemporary Urban Africa, Conference Abstracts: Waste Mangements services, http://www.dbsa.org/inclusivecities/Documents/Inclusive Cities conference - FINAL - abstracts - 010307.doc -

South Africa has a highly developed, largely government owned synthetic fuels industry of which Sasol, a South African integrated energy and chemicals company, produces 36% of the liquid fuels for the country. Other key oil and gas players include: iGas, PetroSA, Petroleum Agency of SA and Petronet. The country has proven oil reserves of 15 million barrels, all of which are located off-shore (2008). Plans are underway to exploit this resource since the majority of oil is currently imported.

Although South Africa has 19 official coal fields, 70% of recoverable reserves lie in just three. The vast majority of consumed coal is used in electricity generation and the synthetic fuel industry. Almost one-third of coal produced in South Africa is exported to the European Union and East Asia[80]. South Africa has an energy intensive economy due to the mining and mineral sector therefore the power industry is extremely important to the country accounting for 15% of its GDP[81].

In January 2008, South Africa had an electricity blackout due to an unexpected growth in demand; the reserve margin fell below 10% and has fallen even lower since. From mid-January 2008, power outages cost the economy USD$253-282 million, half of which was represented by mining losses.

In order to address this shortage, the Department of Minerals and Energy (DME), the National Energy Regulator (NERSA) and Eskom have instigated major energy efficacy initiatives and short term investments in conventional plant as well as renewable projects (mainly solar heating). Their strategy is to invest in new electricity plants and encourage Independent Power Producers (IPPs). There is a particular focus on renewable energy developers involved in solar and wind[82]. Simultaneously, through energy efficiency awareness, the demand will be reduced by 3,000MW before 2012.

The South African government is also committed to ensuring that black-owned companies have access to the energy sector. Under its Black Economic Empowerment (BEE) program, a target of 25% BEE ownership of energy companies by 2014 has been set. Thus large, predominately white-owned corporations have been selling assets to achieve this objective.

Criticism has arisen from Eskom's attempt to recover the R 1.5 billion in infrastructure improvement costs to secure the power supply and a further R 6.1 billion in 2010-2015 by submitting a tariff hike of 35% to National Energy Regulator of South Africa (NERSA). Opponents argue that these costs should be funded by the Environmental Levy proposed by the treasury in July 2009. IPPs make up 3% of the power market capacity, but the government plans to sell 30% of Eskom's stake to IPPs in order to open the market and broaden the remit for securing energy into the private sector[83].

80 US Energy Information Administration (2008) SA: Power Sector profiles, http://www.eia.doe.gov/emeu/cabs/South_Africa/Electricity.html

81 Creamer, T. (Feb 2010) Power Conservation Budget too Low, http://www.greenearthconsulting.co.za/power_conservation_budget_too.html

82 DME (Jan 2008) Energy Efficiancy Launch of the summer savings campaign, http://www.dme.gov.za/energy/GCISEE_QA_V700.pdf

83 Creamer, T. (Feb 2010) Power Conservation Budget too Low, http://www.greenearthconsulting.co.za/power_conservation_budget_too.html

The majority of renewable energy is not provided by modern renewable energy devices but instead by biomass sources like fuel wood and dung. In 2000, less than 1% of electrical demand was generated by renewable technologies; however, this has now risen to about 3.9% today. The renewable energy portfolio is as follows: hydropower (642 MW), solar water heating (652 MW) biomass (200MW), wind (29 MW, of which 23 MW is borehole wind applications) and photovoltaic (12.2 MW). Long term scenarios based on the abundant renewable resources show that renewable energy could meet 50% of the country's electrical demand by 2050[84].

The development of renewable energy in South Africa is still in its infancy with the following small-scale projects currently in the pipeline: 7MW Bethlehem Hydro plant started construction in May 2008; a biomass co-generation project (10MW), in George, is awaiting licence approval; two wave power projects are at pre-feasibility stage; and three wind projects are underway as are residential solar water heating projects. At this time, renewable desalination technology is not in use.

2.1 Grid Infrastructure

Eskom owns and operates the transmission network; over 26,500km of high voltage lines (400 and 275kV) and 365,000km of low voltage lines. *The White Paper on Energy 2003* supports non-discriminatory open access to the grid. Therefore the government is currently unbundling Eskom Transmission and Eskom Distribution into Six Regional Electricity Distributors (REDs) with the intent to open the grid to more IPPs[85].

Network infrastructure has had low levels of investment for decades and serious power failures have resulted from this. Approximately R 300 billion of investment is required in the Electricity Distribution Industry (EDI): on operations, maintenance, refurbishment, asset management, testing, monitoring sills and development over the next five years. This will require both public sector and private support in terms of funding and investment; currently, they are concentrating on the host cities of the FIFA world cup but are aware that nationwide infrastructure management will be required to improve the level of reserve margins.

Eskom is undertaking an R 150 million infrastructural improvement programme[86]. Other developments include the Southern Africa Power Pool (composed of 12 countries) which has been established to ensure capacity and development across the Southern African Development Community (SADC). Financed by the World Bank, large scale grid initiatives are proposed between Mozambique and South Africa[87]. The various stakeholders of the EDI in South Africa have become

84 Holm, D (June 2009) Renewables in Africa (Part 2) http://www.renewableenergyfocus.com/view/2204/renewables-in-africa-part-2/

85 African Wind Energy Association (Mar 2010) South Africa http://www.afriwea.org/en/south_africa.htm. The water sector is divided into the following organisations

86 DME (May 2008) South Arica Wind Energy (SAWEP) Full Size Project, Renewable Energy City Summit, http://www.eskom.co.za/content/Potential%20contribution%20by%20wind%20energy%20in%20SA.pdf

87 Bergman, T (2009) Vattenfall's role in power sector development in southern Africa, http://www.vattenfall.com/en/vattenfalls-role-in-power-sec.htm

increasingly aware that the roles of National Energy Regulator South Africa (NERSA) and the South African Local Government Association (SALGA) need to be clarified and strengthened through legislation, and in particular, the municipal electricity distributors need to comply with their licence conditions in terms of maintenance and security of supply[88]

Abundant renewable energy resources and technologies are available in Southern Africa. The primary objection to widespread use of renewable energy is due to the power intermittency[89]. However, it is estimated that up to 20% of the total electricity supplied can be provided by intermittent renewable energy sources, such as wind and solar, without a significant impact on grid stability (UNDP, 2000)[90]. There is considerable potential for renewable energy to supply the off-grid communities with electricity and clean water.

2.2 Renewable Energy Policy and Strategy

The Department of Minerals and Energy (DME) oversees energy policy and implementation. The DME Hydrocarbons, Energy Planning and Clean Energy Branch regulate and promote integrated energy planning in conjunction with policy produced by the Department for Environmental Affairs and Tourism[91]. The *White Paper on Renewable Energy Policy 2003* supplements the *White Paper on Energy Policy 1998*. Both recognise the significant potential to develop renewable energy technologies within the medium and long-term by encouraging technically feasible renewable energy with funding and investment.

Renewable resources are plentiful but still remain largely untapped. The reliance on coal is set to continue since it is viewed as the most cost effective energy form. The grid system does require more investment and upgrading but they have made significant progress towards providing grid connection to rural areas. The *Electricity Regulation Act 2006* demonstrated plans to open the power market to 30% IPPs / 70% Eskom and create non-discriminatory access to the grid.

The white paper on Energy Policy also presented a programme of restructuring the energy sector by dividing Eskom into separate generation and transmission companies; this has been slow coming into fruition, out of the proposed six Regional Electricity Distributors (REDs) across South Africa, only one is currently operating[92].

South Africa has signed up to the *UN Framework Convention on Climate Change (1997), the Kyoto Protocol (2002), The Bali Conference (2007)* and the latest conference in Copenhagen, which has

88 EDI Summit SA (2008)2008 Electricity Distribution Maintenance Summit http://www.eepublishers.co.za/view.php?sid=10108
89 Diter Holm (June 2009) Renewables in Africa (Part 2) http://www.renewableenergyfocus.com/view/2204/renewables-in-africa-part-2/
90 SANERI (2009) Solar Power- Port Elizabeth, http://www.saneri.org.za/
91 http://soer.deat.gov.za
92 Reform of the Electricity Distribution Industry (EDI) in South Africa: Strategy and Blueprint, February 2001, http://www.ediholdings.co.za/CMS/common/IMG_Generator.asp?varID=93

created a framework for funds via the Global Environment Facility and the Clean Development Mechanism. South Africa made a commitment, along with other participating nations, to promote renewable energy in the *Johannesburg Declaration* (2002). The result of these global commitments is a renewable energy target of 10,000 GWh/yr by 2013.

The projected energy demand for 2013 is expected to be 41.5GW and renewable energy will comprise approximately 4% of this demand. South Africa aims to encourage renewable energy and energy efficacy, promote competition, regulate pricing and tariffs (Renewable Energy Feed in Tariff - REFIT) and create licence opportunities through NERSA. In addition, they aim to improve the compliance and efficiency of regional distributors, secure the energy supply by encouraging more generation through coal plant, renewables and nuclear[93].

Dieter Holm of the International Solar Energy Society (ISES) feels the South African government has been short sighted in favouring conventional energy with short term low costs, largely due to the influence of state controlled monopolies such as Eskom and vested interests from the mining sector. He points out that renewables are a cost effective method in providing decentralised rural energy and that the REFIT mechanisms should go further to encourage renewable energy development across the board.[94]

Pierre-Louis Lemercier, head of the Renewable Energy Centre (REC) South Africa, believes that the goal of cutting greenhouse gas emissions by 34% before 2020 are largely unrealistic due to the country's continuing dependence on coal. The renewable resource potential is enormous and clean development has accelerated partly due to the imminent world cup, which will put a global focus on South Africa[95] but as yet only 10% of the 2013 renewables target has been met, therefore further commitment to exploiting the renewable resource is required[96].

3. SOUTH AFRICAN WATER RESOURCE AND MANAGEMENT

The Infrastructure for water resources and water services requires upgrading. There are skill shortages of engineers, scientists and technical personnel and this therefore leads to fierce competition of skilled personnel. Pollution of water resources from mining, agriculture and industry such as contamination from heavy metals, inefficient agricultural practices, increasing salt loads and eutrophication have all been identified as potentially rectifiable through desalination technology[97].

93 DME (May 2008) South Arica Wind Energy (SAWEP) Full Size Project, Renewable Energy City Summit, http://www.eskom.co.za/content/Potential%20contribution%20by%20wind%20energy%20in%20SA.pdf

94 Holm, D (June 2009) Renewables in Africa (Part 2) http://www.renewableenergyfocus.com/view/2204/renewables-in-africa-part-2/

95 Alternative Energy Africa (Dec 2009) Could SouthAfrica's Goals be Unrealistic? http://www.ae-africa.com/read_article.php?NID=1630

96 Alternative Energy Africa (Nov 2009) Should South Africa Adopt a 25% Renewable Target Wind Power Developer Says, http://www.ae-africa.com

97 DWA (Nov 2008) Water for Growth and Development Water Sector Leadership http://www.dwa.gov.za/masibambane/documents/structures/wsslg/nov08/2.1DG_WSLG_%2013Nov2008.pdf

The Reconstruction and Development Programme (RDP) has attempted to address the need to develop better energy and water services. Much growth and progress has been made in this area, however, there is still a disparity between the basic services for rural and disadvantaged urban areas and developed urban communities. The key stakeholders in the water sector are listed below.

- **Catchment Management Agencies (CMAs**): Management of water resources at catchment level and co-ordinate local community water resource management.
- **Water User Association (WUA):** An association of water users that operates within a given allocation at a localized level (formerly known as irrigation board, now streamlined from 279 down to 38 associations.)
- **Municipal Water Services Authorities (WSA):** Municipality with powers to ensure delivery of water services and sanitation.
- **Municipal Entity:** Public entity at municipal level
- **Water Boards:** 15 have been established as financially independent institutions to operate as water service providers to manage bulk water supply.
- **Water Research Commission:** established to promote the coordination, communication and cooperation in water research (source on desalination studies)
- The Council for Science and Industrial Research (CSIR), carries out water research
- **The South African Local Government Association (SALGA)**, aims to coordinate activity across the municipalities

South Africa has experienced a substantial level of runoff in recent years and the country's dams have been operating at 81% capacity, however some isolated areas have very low storage capacity and drought could rapidly change this picture. The water use per sector is as follows:

- Agriculture 62%
- Domestic 27%
- Urban 23%
- Rural 4%
- Mining 2.5%
- Industrial 3.5%
- Power generation 2.0%
- Afforestation 3.0%[98].

3.1 Water resource and requirements

South Africa is already experiencing climate change. The average land and sea temperatures have increased, the sea level has risen, rainfall has reduced and incidents of extreme weather have increased. The Department of Environment predicts that over the next 50 years the western regions of South Africa will be drier, experience less rainfall and interior air temperatures will increase.

98 DWAF (2009) Multi-Year Stragtic Plan 2009/10-2013-14. http://www.dwa.gov.za/Documents/

These extreme weather patterns will affect the economic welfare of sectors such as agriculture, fishing, tourism and health.

Tide gauge measurements around South Africa indicate that sea levels have risen by approximately 1.2mm/annum over the last three decades[2]. The assumed growth in urban and rural water requirements for industry and households will increase[99].

The following information is based on the most recent water resource statistics for South Africa:

- Rainfall in South Africa is 500mm compared to the global average of 860mm.
- 21% of South Africa has less than 200mm of rainfall per year.
- South Africa is ranked among the 20 most water scarce countries in the world.
- The population density is distributed directly due to water access.
- Ground water makes up 15% of consumption; however 300 towns (65%) of the population rely on groundwater[100].
- The majority of the population live on the coast.
- Most water and power infrastructure is built around the coasts.
- The coastal potential for desalination is massive.

Groundwater is a dependable source of water across the country particularly in rural, arid areas lacking in surface water but in some locations the resource is difficult to access due to impenetrable rock layers; most accessible ground water is in the east, northeast and western cape.

There are six major aquifers including: the Dolomites, Table Mountain Group sandstones, coastal sand deposits, basement granites, Karoo dolerites, and alluvium along perennial rivers. Another obstacle to extraction is contamination from the mining industry. Water containing high levels of chloride, nitrate and other salts would require expensive filtration technologies in order to purify this source.

South Africa has a peak groundwater resource potential of 47 billion m^3/annum, but which can fall to as low as 7 billion m^3/annum in a dry year. The total volume of groundwater available for abstraction in normal precipitation conditions is 19 billion m^3/annum. Currently there are boreholes and aquifer systems across South Africa but they are underexploited as only 6% of groundwater is currently being used[101]. However, access to the groundwater is unevenly distributed across the country.

99 Twomlow, S., Mugabe, F et al (2008) Building adaptive capacity to cope with increasing vulnerability due to climatic change in Africa- A new Approach, Physics and Chemistry of the Earch, Parts A/B/C, vol 33, Issues 8-13, pp 780-787

100 Woodford.A & Rosewarne, P. (2003) How much groundwater does South Africa Have? http://www.anthonyturton.com/admin/my_documents/my_files/SRK_Woodfood_How_much_Groundwater_does_SA_have.pdf

101 Department of Water Affairs and Forestry (2003). Trophic Status of Impoundments. Department of Water Affairs and Forestry, Pretoria. http://www.dwaf.gov.za/IWQS/eutrophication/NEMP/default.htm

Overall the picture of economic and infrastructural growth, renewable objectives and the fact that water shortages are impending should open the opportunity to present renewable desalination technology as a viable option in South Africa.

3.2 Access to Water

Since 1994, there has been an enormous improvement in access to clean water. In 2001, 9.5 million households (84.5%) had access to piped water - an increase of 2.4 million households since 1996. The number of households relying on water from dams, rivers and boreholes declined during this same period, which suggests improved access to clean water among rural households.

In 2008 it was estimated that 2.4 million South Africans did not have access to basic water services[102].In rural areas, where water supply is accessible, the quality is often unsuitable for drinking. In 1994 diarrhoea caused 43,000 deaths and 3 million illnesses. Target 10, Goal 7 of the Millennium Development Goals requires a 50% reduction in households without sustainable access to safe drinking water and basic sanitation.

The 2009-2014 Strategic Plan outlines a strategy to provide: universal access to safe and affordable drinking water; build, operate and maintain infrastructure; align and promote efficacy of water institutions; pursue African advancement through international cooperation with the SADC region and African Ministers Council on Water (AMCOW). They state that the job will not be complete until the last person in the remotest village has access to drinking water. It is hoped that this can be achieved by 2030[103]. However, water infrastructure needs to be updated and the diversity of water sources increased to meet future demand[104].

3.3 Water policy and strategy

The Department of Water Affairs and Forestry (DWAF) has overall responsibility for managing the water sector and meeting water targets. The legal framework includes: *Water Research Act, 1971* developed to promote water affairs research, *The Water Service Act 1997* set out guidelines to streamline services and aims to provide access to basic water supply and sanitation.

The *National Water Act, 1998*: set out objectives for management of water resources in order to protect, manage and control the resource[105]. They have attempted to address the fragmented water apparatus through *Integrated Rural Development Programme* (IRDP) and the *Urban Renewal Programme (URP)* which has made good progress on housing, health, electricity, communications,

102 Department of Water Affairs and Forestry (2004). National Water Resources Strategy. Department of Water Affairs and Forestry, Pretoria, http://www.dwaf.gov.za

103 DWAF (2009) Multi-Year Stragtic Plan 2009/10-2013-14. http://www.dwa.gov.za/Documents/

104 Twomlow, S., Mugabe, F et al (2008) Building adaptive capacity to cope with increasing vulnerability due to climatic change in Africa- A new Approach, Physics and Chemistry of the Earch, Parts A/B/C, vol 33, Issues 8-13, pp 780-787

105 DWAF (2009) Multi-Year Stragtic Plan 2009/10-2013-14. http://www.dwa.gov.za/Documents/

potable water supplies and sanitation. They have also invested in large infrastructural projects such as the Berg Water Project and are financing desalination projects in various municipalities[106].

However many remote communities, still lack a basic water supply, are heavily reliant on grants and are not economically self-sufficient. The barriers preventing implementation of their goals have been found at a municipal level with delivery of strategy failing. Many Water Service Authorities have not complied with the regulations of the *Water Services Act 1997* and have failed to provide water service delivery without interruptions.

The South African government have worked to encourage cross communication on best practice through national departments, the South African Local Government Association (SALGA), individual municipalities and water authorities to ensure the *National Water Infrastructure Resource Strategy* and the *Water Demand Management Strategy* can be implemented effectively [107]

The Department of Water Affairs and Forestry (DWAF) is continuing to carry out water assessment studies known as reconciliation strategies in order to reconcile the supply and demand for water. These strategies aim to ensure the supply of water at adequate levels of assurance within the constraints of affordability, appropriate levels of service to users, and the protection of current and possible future water resources. Thus far, six studies have been undertaken in the major urban centres and by 2011 reconciliation strategies will be completed for every town in the country.

As part of the *Water Growth and Development Strategy 2009* the department will invest heavily in diversifying the water mix in which desalination is cited for the treatment of effluent and sea water. One of the key strategies is to provide the water source close to the end user to save on infrastructural costs. They also want to focus on water conservation, demand management and water efficacy.

DWAF analysis has found that a lack of technical skills, funding and management must be addressed immediately. They see a symbiotic relationship between water access and economic development and will push to make water policy a priority across government sectors[108].

4. SOUTH AFRICAN FUNDING AND INVESTMENT

4.1 Government Funding

The Integrated Energy Plan 2003 set out a framework for encouraging investment in renewable energy. However, investment in conventional energy plant is much larger than any renewable

106 DWA (2009) Water Growth and Development Strategy, http://www.dwa.gov.za/WFGD/documents/WfGDexecutivesummary.pdf

107 DWAF (Sep 2004) SALGA CONFERENCE: 'BUILDING SUSTAINABLE COMMUNITIES', ADDRESS BY MS B SONJICA, MINISTER OF WATER AFFAIRS AND FORESTRY, http://www.search.gov.za

108 DWA (2009) Water Growth and Development Strategy, http://www.dwa.gov.za/WFGD/documents/WfGDexecutivesummary.pdf

investments to date. Fiscal resources have been limited by the fact so much investment has been allocated to infrastructural and economic equalising post apartheid.

The upside of ratifying agreements such as the Kyoto Protocol has meant that South Africa has had the opportunity to raise funds via the Global Environment Facility and the UN Clean Development Mechanism, which will be used to fund renewable energy projects during 2009-2014.

Fiscal incentives for renewable energy include: the Renewable Energy Feed in Tariff (REFIT) and a levy of two cents per kWh on conventional power sources in order to gather revenue for financing energy efficacy and renewable energy. This levy is expected to raise R 2billion during 2008/09 and R4 billion a year thereafter. The renewable energy subsidy for 2009/10 was R5,678 million and for 2010/11 it will be R5,962 million[109]. The Department of Minerals and Energy (DME) has established the Renewable Energy Finance and Subsidy Office (REFSO) to manage renewable energy subsidies and advise developers on financing[110].

The South African economy has seen growth in the past five years with over two million new jobs created. However, the global economic downturn affected South Africa, and thus the economy shrank by 1.8% in 2009. During this year 900, 000 people lost their jobs and the key industrial sectors such as mining suffered from a reduction in sales.

It is predicted that in 2010 the economy will grow by 2.3%, rising to 3.6% growth by 2012. South Africa is investing in rural development by establishing a R1.2billion, three year grant scheme dedicated to developing water, sanitation and housing infrastructure. Local governments will receive a further R6.7 billion to support municipalities in subsiding water and electricity to disadvantaged households. Total allocations to municipalities will rise from R55 billion in 2009/10 to R78 billion in 2012/13. The national government has made a total of R52 billion available for public works projects over the next three years. Extensive planning and consultation is in progress on infrastructure programmes for the next 10-20 years.

A guarantee of R15.2 billion has been approved for the Development Bank of Southern Africa, enabling it to extend capital to less developed municipalities for infrastructure projects. The Industrial Development Corporation (IDC) is well funded and will continue to play a crucial role in implementing the government's Industrial Policy Action Plan[111]. South Africa is also benefiting from the following bank investments:

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109 Fakir, Mahesh (Feb 2008) Presentation from National Treasury, http://academic.sun.ac.za/crses/pdfs/7)%20Wave%20energy%20conference-NT%20%20BUDGET%20PROCESS%20M%20Fakir.pdf

110 www.dme.gov.za/energy/renew_finnace.stm

111 All Africa (Feb 2010) SA: Budget Speech 2010, Minister of Finace, Pravin Gordhan, http://allafrica.com/stories/201002170716.html?page=6

The European Investment bank (EIB)

The EIB has lent €40 million to the First Rand Bank to promote renewable energy and energy efficiency projects across South Africa as part of an ongoing mandate for funding and EU renewable energy goals. In 2007 EIB pledged a loan of €900 million to the republic until 2013. The total value of eligible projects is €100 million of which EIB will contribute 40%. Specific focus is on industrial cogeneration, but support will be provided to other renewable energy schemes and energy efficiency initiatives. In 2008 EIB supported sustainable economic development in South Africa by investing €202.5 million in three projects, almost doubling its financing activity compared to €113 million in 2007[112].

The World Bank

The World Bank will provide USD$500 million through the Clean Technology Fund (CTF) Investment Plan in South Africa in order to enable it to meet national sustainability targets. The South Africa investment plan is endorsed by the Central Technology Fund (CTF) as part of the wider Climate Investment Fund (CIF) aimed at improving the commercial development of renewable energy from demonstration to commercial projects. The CTF is composed of funding pledged by the US, Australia, France, Germany, Japan, Spain, Sweden and the UK. The CTF will gather financing of USD$1 billion from the public and private sector which include the South African government, the African Development Bank, the World and the International Finance Corporation. Eskom will build a 100MW Concentrated Solar Power (CSP) plant, the first of its kind in South Africa and the Western Cape Province Wind Energy Facility (100MW wind farm) with CTF funding[113].

The Central Energy Fund (CEF)

The CEF group operates PetroSA, iGas, Petroleum Agency SA, OPCSA, SANERI, The National Energy Efficiency Agency (NEEA), the Strategic Fuel Fund Association (SFF) and Energy Development Corporation (SFF). The CEF group of companies focuses on gas and oil exploration, oil trading, petroleum products, but has established the Energy Development Corporation (EDC) to pursue commercially viable renewable energy investments[114].

4.1.1 Renewable Energy Feed-in Tariff (REFIT)

The Feed-In Tariffs (FITs) are based on the levelised cost of electricity and a full methodology is displayed below. Reduction rates and carbon revenue from clean development mechanism (CDM) are excluded from REFIT.

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112 Renewable Energy Focus (Dec 2009) Eurpoean bank funds renewable energy in SA, http://www.renewableenergyfocus.com/view/5635/european-bank-funds-renewable-energy-in-south-africa

113 Renewable Energy Focus (Nov 2009) World Bank funds half-million for renewable energy and efficiency in SA, http://www.renewableenergyfocus.com/view/5488/world-bank-funds-halfmillion-for-renewable-energy-and-efficiency-in-south-africa

114 http://www.cef.org.za

Currently Phase I of the REFIT includes technologies displayed in the table below. Phase II will include concentrated solar (without storage), biomass (solid), biogas, photovoltaic systems (large ground or roof mounted concentrating photovoltaic (CPV)) and concentrated solar (CSP) central tower. Wave, tidal and geothermal technologies will be considered in future once they are further advanced to commercialisation.

REFIT Phase II only includes power generation that can be connected to the national grid and excludes off–grid power generation. A Renewable Energy Power Purchase Agency (REPA) will be run by Eskom Holdings Ltd as a single buyer office and will be facilitated by NERSA, who will award IPPs the right to participate in the REFIT scheme. REPA will be obliged to purchase renewable energy in order to encourage the market. An Independent Power Producer (IPP) can also sell directly to buyers outside the REFIT mechanism but will require a generation licence under no.4 of the Electricity Regulation Act 2006. They will also be responsible for the design, engineering, construction, finance, maintenance, commissioning and operation of the REFIT power they supply[115].

Renewable	**Unit**	**REFIT**
Concentrated Solar	R/kWh	2.10
Landfill gas	R/kWh	0.90
Small Hydro	R/kWh	0.94
Wind	R/kWh	1.25

Table 2: South Africa Renewable Energy Feed in Tariff.

The South African government is keen to encourage private investment in sustainable projects. Various studies have shown that clean energy investments are down globally with worldwide clean energy investment totalling $145 billion in 2009 which represents a decrease of 6.5% on the previous year. Private equity and venture funds have reduced investments by 44% in 2009116. The various equity funds available are listed below:

5. SOUTH AFRICAN RENEWABLE ENERGY RESOURCES

5.1 Wind Power

Wind power has great potential in South Africa, particularly along the coast, in certain locations average wind speeds are above 6 m/s. There is also a moderate wind resource on inland high ground areas. In 1998 it was estimated that South Africa could generate 3GW of power from onshore wind energy.

115 NERSA (July 2009) Renewable Energy Feed-In Tariff (REFIT), Phase 2 July 2009 consultation Paper, http://www.nersa.org.za/UploadedFiles/ElectricityDocuments/REFIT%20Phase%20II%20150709.pdf

116 Creamer, T. (2010) Global investments in clean energy fell less than expected in 2009, http://www.greenearthconsulting.co.za/global_investments_in_clean_energy_fell_less_than_expected_in_2009.html

Boreholes and locally constructed wind-pumps have a long history of use for accessing ground water on a small-scale[117]. Small companies like Turbex supply windmills to power water pumps with a production rate of 1000 litres/hr over a distance of 15km[118]. Desalination devices are often included to filter nitrates and other such substances. Large scale wind turbine projects are expected to increase across the African continent. The consultants, Frost & Sullivan, estimate that the South African wind turbine market could reach USD$422.3 million in 2015 compared to USD$148.4 million today. This increase is based on a change in perception towards wind energy due to the establishment of a successful wind industry in Europe and the United States[119].

The potential for wind power desalination of seawater is promising in terms of resource. The Council for Scientific and Industrial Research in South Africa has produced various papers suggesting that wind-pumps and boreholes, which are familiar to off grid communities, should be further exploited to address the impending water crisis, to access untapped ground water and address grid infrastructural cost by supplying off grid power to rural areas[120].

Eskom ran the Klipheuwel 3.2MW pilot wind farm from 2002- 2005[121]. However, Eskom does not see a bright future for wind energy in South Africa as they believe the country to have only moderate resources compared to Northern Europe[122]. Located 70km north of Cape Town, the 5.2MW Darling wind farm demonstration project was the first IPP (Darling Wind Power) of its kind in South Africa.[123] The project cost R70-75 million and investors include; the Central Energy Fund (CEF) of the South African government, Darling Wind Power, the Development Bank of South Africa and Dandia (a Danish government development fund). The City of Cape Town has a twenty year Power Purchase Agreement for the electricity produced by the farm[124].

Current proposed wind farm developments include: the 60MW Coega Commercial Wind Farm Project located in the Coega Industrial Development Zone (IDZ). Electrawinds, the project developer will invest R1.2million and it is hoped to be operational by 2011[125]. Renewable Energy Systems, a UK based company, has been encouraged by the new REFIT scheme and are at the early stages of development for up to 300MW in wind farm projects along the Eastern and Western Cape[126].

117 http://www.villageearth.org/pages/Appropriate_Technology/ATSourcebook/Energywind.php

118 http://www.turbex.co.za

119 Alternative Energy Africa (Jan 2010) Wind Turbine Sector on the Rise in SA., http://www.ae-africa.com/read_article.php?NID=1713

120 CSIR (Sep 2009) Groundwater: The Key to SA Water Security, 2009http://csir.co.za/nre/docs/BriefingNote2009_03_Groundwater_final.pdf

121 Afriwea (2008) Energy Sector: SA, http://www.afriwea.org/en/projects.htm

122 South Arica Info (Nov 2006) Green light for SA’s wind farm, http://www.southafrica.info/about/sustainable/windfarm-darling.htm

123 South Arica Info (Nov 2006) Green light for SA’s wind farm, http://www.southafrica.info/about/sustainable/windfarm-darling.htm

124 DME (May 2008) South Arica Wind Energy (SAWEP) Full Size Project, Renewable Energy City Summit, http://www.eskom.co.za/content/Potential%20contribution%20by%20wind%20energy%20in%20SA.pdf

125 Coega IDZ (2010) Electrawinds, http://www.coega.co.za/Content.aspx?objID=39

126 Alternative Energy Africa (Jan 2010) SA adds another brit to the RE mix, http://www.ae-africa.com/read_article.php?NID=1731

Mainstream Renewable Power formed a joint venture with South African wind farm developer, Genesis Eco-Energy, in March 2009 to build two 70MW projects in Jeffery's Bay and Colesberg that are expected to be fully operational in early 2011[127]. Exxaro (South Africa Mining group) is developing a 100MW wind farm at Brand se Baai and is hoping to sell the electricity back to the national grid and develop more wind farms[128].

5.2 Solar Power

Daily solar radiation varies between 4.5 and 6.5 kWh/m² (16 and 23MJ/m²). The potential uses and current applications include: solar water heating (being implemented), solar space heating (buildings), solar cookers (alternative to the fuel wood used extensively in rural areas), solar greenhouse (crop drying-agriculture) and electrical use such as domestic standalone systems or large-scale photovoltaic (PV) arrays.

The PV systems are widely applied to powering cellular communication networks in South Africa and the potential for large grid-connected applications is also recognised. Installed PV capacity was measured at 8MW (2000).

Solar thermal plant have the potential to cover 194 000 km² of South Africa and have an installed potential of 64.6 GW. Indentified barriers include backup and storage capacity, weak legislative and fiscal incentives. It is believed that 18% of urban residential consumption can be met by solar-electric water heating systems.

Solar panels have also been used to power borehole pumps such as the Lynedoch Ecovillage Trunz system[129]. The main drawback to solar energy has been its installation cost – estimated at about R22 (USD$2.80) per watt-peak, which equates to a cost of about R1.5/kWh (USD$0.23/kWh). In contrast, with such an abundance of coal, South Africa currently produces the world's cheapest electricity at about R0.4/kWh (USD$0.06/kWh). However, with fast-improving technology, experts are predicting solar panel prices will hit USD$0.99 per watt-peak in the near future[130].

South African Professor, Vivian Alberts, a physicist at the University of Johannesburg (RAU), has developed a variety of semiconductor thin films for solar cell applications. Attention is mainly focused on the growth and characterization of polycrystalline ternary and quaternary semiconductors such as $CuInSe_2$ and $Cu(In,Ga)Se_2$.

One 50 Watt-peak panel produces approximately 250Wh/day. These solar panels are now ready for commercial use, and are expected to cost about R14 (USD$1.80) per Watt-peak. Professor Alberts is

127 Alternative Energy Africa (Nov 2009) Should SA Adopt a 25% Renewable Target Wind Power Developer Says, http://www.ae-africa.com

128 Alternative Energy Africa (Feb 2010) SA's Exxarao to Increase National Grid, http://www.ae-africa.com/read_article.php?NID=1759

129 DME (Aug 2002) White Paper on the Promotion of Renewable Energy and Clean Energy Development http://www.info.gov.za/view/DownloadFileAction?id=68781

130 Total Solar UK (2009) Will SA Lead The Solar Energy Surge, http://www.totalsolarenergy.co.uk/solar-energy-south-africa.html

project leader of the photovoltaic research group at RAU, the group has also developed the unique ability to produce and evaluate completed solar cell devices and mini-modules. The group actively collaborates with various national and international groups and receives financial support from the National Research Foundation and Volkswagen Foundation in Germany[131].

There are no notable solar desalination projects in South Africa, however future water scarcity combined with a significant solar resource translates into a strong potential market. The country's solar-equipment industry is growing; more companies in South Africa are selling solar panels[132] and other related solar energy products[133]. There are also a number of solar deep well pump and borehole suppliers such as ICM industries who supply various versions of solar pumps to South Africa and surrounding countries[134]. Given the right market incentives and cross communication, desalination developers could work with the South African administration to implement a robust solar desalination market.

5.2.1 Solar Water Heating

Eskom has implemented a solar powered water heater incentive programme. The programme is aimed at urging home-owners and businesses alike to move towards renewable sources of energy - especially solar energy. The Nelson Mandela Bay Municipality (NMBM) is currently in the process of installing 1200 solar water heaters on homes in Chatty, which forms part of the Zanemvula Housing Project, sponsored by the Development Bank of South Africa. The solar water heaters will heat water with no cost to the households. Three hundred units have been installed so far and have contributed to local job creation, particularly for women residing in the local area[135].

The Central Energy Fund (CEF) received 180 bids in response to an advertisement seeking interested parties for the supply of solar water heaters (SWHs) for the initial phase of a major project roll-out in Port Elizabeth. The residential districts in Nelson Mandela Bay could support 100,000 SWHs. An installation target of 60,000 units has been set over the next five years which could potentially save 41MW. The project will qualify for the demand-side management (DSM) subsidy administered by Eskom for suppliers who meet approved solar standards. Each system costs R17,000 but if it is fully implemented, this could drop to R12,000 and receive further funding from the Clean Development Mechanism[136].

5.2.2 Solar Electricity

A solar panel manufacturing plant is planned for Paarl, Western Cape, using thin-film solar panels developed by Professor Vivien Alberts, project leader of the photovoltaic research group at Johannesburg University. The technology is being tested in Germany and will be transferred back to

131 http://www.sessa.org.za/renewable-energy/solar-photovoltaic-energy
132 http://www.solarbuzz.com/CompanyListings/SouthAfrica.htm
133 Sustainable Energy Society SA- SESSA (Oct 2009) Solar Power, http://www.sessa.org.za/renewable-energy/solar-photovoltaic-energy
134 www.icmsa.co.za
135 http://www.nelsonmandelabay.gov.za
136 Van Der Merwe, C. (Aug 2009) 180 bids received for Port Elizabeth solar water heater project, Engineering News Online

South Africa. This is a joint project between Germany, SASOL and the European Investment Bank. Shareholders include the Central Energy Fund, the National Empowerment Fund and the University of Johannesburg. They aim to implement the project within the next two to three years[137].

Exxaro (South African Mining Group) is planning a 200MW concentrated solar power plant in Limpopo and is currently conducting prefeasibility studies[138]. Eskom is building a multi-million dollar solar plant near Upington in the Northern Cape - the first major solar energy initiative on the continent[139]. The Solar Electric Light Fund, Inc. (SELF) is a non-profit, charitable organization that has helped implement solar electricity in schools in KwaZulu-Natal and plans to develop more projects[140]. Johannesburg Roads Agency (JRA) and Eskom have been installing solar powered traffic lights in Johannesburg in order to address frequent blackouts[141].

5.3 Wave Power

South Africa has a significant offshore wave power resource. The estimated power per metre of wave front is approximately 20-40 kW. It is believed that by 2013 up to 24 MW of wave power could be installed off the coast of South Africa. The future potential resource could contribute 8 – 10GW towards the South African electricity supply. The most promising areas include the west and south coasts.

Desalination of seawater for limited productive use in coastal locations is considered highly feasible. Desalination for coastal locations will require implementation mechanisms to effect changes such as regulatory and market-based instruments, self-regulation, awareness and education[142]. As yet there are no plans to implement any ocean energy desalination projects.

Industrial uses of the marine environment consist of numerous activities such as: fish processing, salt production, limited desalination, aquariums and oceanariums, industrial harbours and ports, cooling water (nuclear power plant), coastal mining, marine outfall systems, exploration drilling, scrubbing and scaling (smoke stack emissions[143]).

The South African National Energy Research Institute (SANERI), Eskom Research and Innovation Department (ERID) and the Department of Sustainable Energy Studies at Stellenbosch University

137 Alteranative Energy Africa (Nov 2009) Solar Plant Moves forward in SA, http://www.ae-africa.com/read_article.php?NID=1574
138 Alternative Energy Africa (Feb 2010) SA's Exxarao to Increase National Grid, http://www.ae-africa.com/read_article.php?NID=1759
139 Total Solar UK (2009) Will SA Lead The Solar Energy Surge, http://www.totalsolarenergy.co.uk/solar-energy-south-africa.html
140 http://www.self.org/southafrica2.shtml
141 Northside Chronicle (Feb 2008) Solar Energy Fights Traffic Blackouts, www.saneri.org
142 DWAF (Mar 2009) Securing South Africa's Future Water Needs: Framework for Action, www.dwaf.gov.za
143 DWAF (2004) Water Quality Management Series, Section 4: Environment Quality Objectiveshttp://www.dwa.gov.za/Dir_WQM/docs/marine/MarineWasteImplementationOct04Sec4.pdf

have embarked on a joint collaboration to promote research and demonstration of ocean energy technologies with the aim to establish a Wave Test Centre and ocean energy data site[144].

In 2002 the SABRE-Gen Wave Project (run by Eskom) investigated the potential of using Wave Energy for bulk electricity generation in South Africa. The project estimated the annual average wave power density of 17kW/m and an average winter wave power density of about 30kW/m. These results encouraged Eskom to continue research and in 2004 they completed a techno-economic and technology selection study to identify wave technology development globally. At the time it was decided most appropriate to wait until these technologies were more commercially viable. In 2007 they embarked on a Strategic Environmental Assessment to define suitable sites.[145].

Two wave projects are at proposal stage; Finavera Renewables, Canada, is currently conducting a micro-site analysis off the Western Cape and with the assistance from government agencies, they are currently in the process of assessing the permits required for this project. As part of the Clinton Global Initiative, Finavera has committed to the development of a 20 MW project[146]. Pelamis Wave Power participated in South Africa's first Ocean Energy Workshop in 2008 and has subsequently initiated project feasibility studies[147].

6. SOUTH AFRICAN DESALINATION

The Department for Water Affairs and Forestry (DWAF) has set a desalination target for coastal municipalities and inland saline water sources. Inland areas do not yet receive water from desalination due to the cost of implementing the infrastructure required to pump water long distances.

Desalination forms part of the Department of Water Affairs and Forestry's (DWAF) strategy to counter drinking water scarcity. The process of desalination has been used traditionally in industry and for the treatment of brackish water in boreholes. The Albany Coast Water Board, Eastern Coast has approved R2.47 million from the DWAF and a further R1.6 million from the Kenton Eco-Estate (private real estate developer) to refurbish three desalination plant in order to meet demand[148].

Several plant are in use to treat brackish ground water in the western parts of South Africa. Desalination has also been implemented by: Eskom at Tutuka power station; Sasol Mining in Secunda; and at the Emalahleni Water Reclamation Project in Witbank. Desalination technology has been used on Robben Island and the Eastern Cape towns of Kenton-on-Sea and Bushman's River

144 PWP (2008) workshop on Ocean Energy, http://www.pelamiswave.com/media/sa_workshop.pdf

145 http://www.sabregen.co.za/wave/wave-project.html

146 http://www.finavera.com/files/2007-12-18%20Finavera%20Renewables%20signs%20power%20purchase%20agreement%20with%20PG&E.pdf

147 www.pelamiswave.com

148 DWEA (Aug 2009) Question No 790- Internal Question paper No 9, www.dwea.za

Mouth[149]. Mossel Bay, George and Bitou are all at various stages of acquiring reverse osmosis plant[150].

The City of Cape Town's CMA Bulk Water Supply Study (April 2002) investigated the desalination potential at Melkbos and the Koeberg Nuclear Power station. Results suggested, that combined, they could produce 60 million litres of potable water per day. Both sites were located on the coast, had available inlet structures, energy supply, water infrastructure and a high demand for water from the rapidly urbanising Blaauwberg area[151].

In the Western Cape and in Cape Town residents already live under tight water restrictions, and this is set to continue due to a growing urban population. Theoretically, desalination is an unlimited source of water.[152]

The DWAF estimates the cost of desalination, including both capital redemption and operational cost, to be in the region of R5 and R8 per 1,000 litres (1 kilolitre). The cost of groundwater desalination has a lower cost than seawater desalination. By comparison the cost of conventional treatment is around R1 to R3.50 per kilolitre, where the raw water is fresh and does not require desalination[153]. However Grahamtex Systems, the contractor at the new Sedgefield Desalination plant, now claims to be producing potable water for R3 per kilolitre. This is cheaper than the price paid by most South Africa consumers for municipal water[154].

In a water research commission guide for municipalities entitled, "*A Desalination Guide for South African Municipal Engineers",* it is indicated that while desalination is more costly than conventional treatment, the quality of desalinated water is of a higher standard than conventionally treated water. Knysna municipal officials are pleased with the desalination plant at Sedgefield and cite its modular system as an advantage by allowing a gradual increase in production which spreads the upfront cost into manageable capital investments[155]. The Framework on Water for Growth and Development 2009, recommends that "full feasibility studies be undertaken for desalination of seawater at all major coastal cities." However it is not the function of the department to plan actual desalination plant, it falls to the municipalities to initiate such projects and apply to the department for approval and funding[156].

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149 Wilkson, K. (Oct 2009) SA's biggest desalination plant set for Sedgefield, http://www.theherald.co.za/gardenroute/article.aspx?id=479656

150 Oelofese, N. (Dec 2009) Knysna sold on reverse osmosis purifying process, http://www.weekendpost.co.za/article.aspx?id=526828

151 `DWAF (April 2002) Section H- Desalination, Western Cape Reconciliation Strategy, Screening of Options Workshopwww.dwaf.gov.za

152 `Cohen, L (Oct 2009) Drinking water from the sea,http://www.timeslive.co.za/news/article137646.ece

153 `DWAF (May 2003) Draft Speech: Western Cape Water Summit, http://www.dwa.gov.za/Communications/MinisterSpeeches/Kasrils/2003/M292-2003-SPEECH.pdf

154 `Wilkson, K. (Oct 2009) SA's biggest desalination plant set for Sedgefield, http://www.theherald.co.za/gardenroute/article.aspx?id=479656

155 `Oelofese, N. (Dec 2009) Knysna sold on reverse osmosis purifying process, http://www.weekendpost.co.za/article.aspx?id=526828

156 `DWA (May 2007) Written Reply to Question 741- Whether desalination forms part of herdepartment's strategy to counter water scarcity, http://www.dwa.gov.za/search.aspx#

The 800 m^3/day Ikusasa desalination plant is currently under construction for Overberg Water in the Western Cape. Ikusasa water will utilise locally manufactured advance ultra-filtration membrane technology developed by the University of Stellenbosch. This will be the first instance where the technology has been demonstrated. The Water Research Commission (WRC) funded the development of local ultra-filtration membranes and treatment systems at the University of Stellenbosch over the last 15 years. The WRC holds four separate patents for this technology and the Department of Trade and Industry is also funding the project which is expected to be operational in May 2010[157].

Another local company, Keyplan, has supplied membrane based solutions and desalination devices to industry in South Africa since 1989. They provide reverse osmosis technology for seawater, mine water, boiler desalination and electrically driven ion exchange (EDR) membrane technology for desalinating brackish waters[158].

157 Desalination Biz News (Feb 2010) First indigenous UF plant to open in South Africa in May, http://www.desalination.biz/news/news_story.asp?id=5209

158 http://www.keyplan.co.za/about.html

6.1 South African Desalination Projects

There are a number of desalination projects in South Africa; below are details of two of these projects.

6.1.1 Sedgefield Desalination Plant: Large Scale Implemented

Location	Sedgefield seaside town, Knysna municpality
Partners	The Knysna municipality (client), the Department of Water Affairs and Forestry as well as Graham Tex systems (contractor) signed contracts in Oct 2009. Project manager is SSI Engineers.
Value	Total: R16 million Construction: R10 million 2.5km pipeline: R6 million
Funding	Department of water Affairs and Forestry. The municipality has used resources from the 2006 disaster fund. Additional contributions include a municipal infrastructure grant as well as a bulk infrastructure grant from the National Water Affairs department[159].
Technology	Modular design Reverse Osmosis – pressure is re-used which saves up to 40% of the electricity required to operate the plant. Costs of producing potable water are R3 per m^3.
Power supply	Unknown
Status	Environmental Impact Assessments are being conducted by Cape Environment Assessment Practitioner on the Myoli beach - thus far results have been promising. No increased salinity has been detected beyond 10 metres of the discharge wells. The wells and discharge wells are buried 1.5m below the sand so there is no visual disturbance to the beach. The Knysna municipality have signed a deal with Grahamtek to recycle the town's effluent waste to produce two million litres of potable water a day by March 2010.

159 Cohen, L (Oct 2009) Drinking water from the sea,http://www.timeslive.co.za/news/article137646.ece

6.1.2 Solar/Wind Water Filtration System at the Lynedoch EcoVillage[160]: Small Scale project

Location	The Sustainability Institute, Lynedoch EcoVillage, 15 km from the town of Stellenbosch.
Partners	Trunz Water Systems (swizz manufacturer), Water4all (Trunz supplier, SA), The Sustainability Institute of Stellenbosch University (funder).
Value	N/A- Trunz does not provide price lists on its website.
Funding	Sustainability Institute of Stellenbosch University[161].
Technology	The TWS 100 system installed at Lynedoch is made up of 3 solar panels and 1 wind turbine, with a motor for pumping water and ultra-filtration and membrane filter for purifying water. It provides 20 m^3 of clean potable water a day. It can run 24 hours a day and comes complete with a borehole type delivery pump.
Power supply	Unknown
Status	A solar/wind powered water purification system (Trunz) was installed in 2007 at the Lynedoch EcoVillage. Distributed by Water4all[162], the Trunz Water System (Switzerland) distributer in South Africa is working in conjunction with the Sustainability Institute of Stellenbosch University[163].

160 Although this is not a desalination project it is an example of how the use of renewable energy is proposed to be used in South Africa to provide water for consumption.
161 http://www.sustainabilityinstitute.net/
162 www.water4all.co.za
163 http://www.sustainabilityinstitute.net/home-mainmenu-33/140-new-solarwind-water-filtration-system-at-the-lynedoch-ecovillage

7. RENEWABLE ENERGY DESALINATION MARKET POTENTIAL

Water shortages and increasing water prices are predicted in South Africa over the next 20 years. The majority of South Africa's population reside along the country's 2,798 km coastline which indicates that desalination would be a logical option. However, it is often cited in DWAF reports as prohibitively expensive where challenges such as electricity supply and regulated disposal of brine have to be overcome.

Research carried out by the Water Research Commission estimated that the city of Cape Town could produce potable water from desalination at a cost of R5.8 to R8.3 per cubic metre. This is in line with the advancements in membrane technology which have reduced costs through increased energy efficiency[164]. As yet the solution for renewable desalination technology has not been fully investigated by the South African government, but the South Coast municipalities have conducted desalination feasibility studies over the past two years and have concluded that cost is the primary barrier[165].

According to Frost and Sullivan, the South African membrane market earned revenues of USD$37.5 million in 2007 and predicts this will rise to USD$143.9 million by 2014. Improvements in membrane technology costs have, and will continue to encourage demand in South Africa. This technology is being applied to potable water for municipalities as well as the industrial sector use for wastewater recycling.

The cost of maintaining membrane systems that require a regular replacement schedule is a financial barrier which is exacerbated by the cost of powering such ventures with electricity. However, the life-cycle costs are comparable to other technologies and should be used as a selling point. Frost & Sullivan predict that desalination plant will become more common in South Africa and that accepting the increase in water prices must be taken on board in order to develop the sector as a whole[166].

There is considerable resource potential for renewable technology and South Africa must begin implementing more renewable projects if they are to achieve their 2013 targets. Funding for such projects is limited due to constrained fiscal resources; however there are investments coming from development banks as well as equity funds that are large and specifically targeted at aiding sustainable development in South Africa.

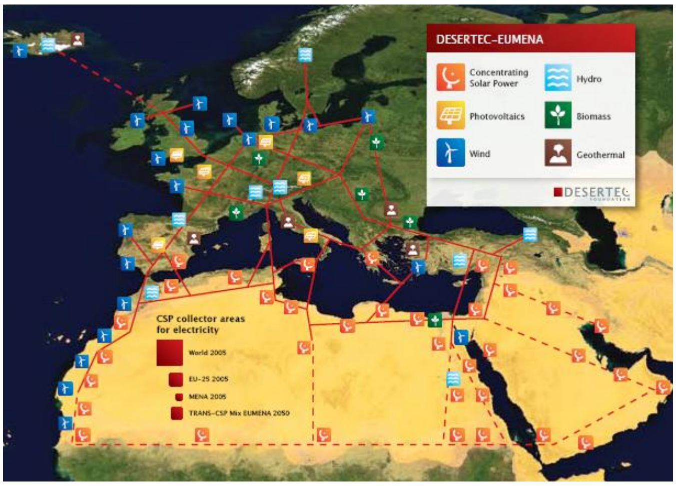
164 Winter, D- Frost and Sullivan (May 2007) Climate change, urbanisation and impending water shortages: is desalination the answer to South Africa's Water Issues? http://www.frost.com/prod/servlet/market-insight-print.pag?docid=98727600&ctxixpLink=FcmCtx29&ctxixpLabel=FcmCtx30

165 DWA (Feb 2008) Water Reconciliation Strategy Study for the Kwazuli-Natal Coastal Metropolitan Areas, http://www.dwa.gov.za/Projects/KZNWaterRecon/documents/KZN_SCC28Feb08wq.pdf

166 Frost and Sullivan (Nov 2008) South Africa Membrane Market, www.frost.com

Renewable desalination developers are best placed to inform the department of Water Affairs about adding renewable desalination to the water mix as there is limited recognition in government literature. Desalination and renewable energy must to be presented as a married concept to relevant departments such as water, energy, environment and economic development. To initiate projects, developers must first identify municipalities in water scarce locations and then communicate the concept of renewable desalination technology and its potential to provide potable water at a competitive price.

Middle East & North Africa



EXECUTIVE SUMMARY

The Middle East and North Africa (MENA) region contains many states where the cultural and political systems are very different from those in Europe. This can create problems when trying to initiate renewable energy desalination projects in the region and the challenges associated with this potential barrier should not be under-estimated. In addition, many countries in the region have vast reserves of oil and gas and are currently heavily dependent on this energy source. This means that in many countries in the region there is limited support for renewable energy and research in this area is underfunded. However, this perspective is slowly changing and the region is starting to accept that it must diversify away from oil in the future. A consequence of the large revenues from oil and gas mean that there is potentially a large funding pool for the development of new technologies.

The MENA region has a large renewable energy resource, primarily solar and wind energy that could be exploited to power desalination projects. In addition, the region has a significant shortage of water and that the situation is expected to worsen due to predicted population growth and increased industrialisation. Consequently, the region is ideally suited for the development of renewable energy desalination projects where there is political will. Morocco is an example of a country in the region that has recognised the need for increased exploitation of its renewable energy resource and also has a shortage of fresh water.

1. OVERVIEW OF THE MIDDLE EAST AND NORTH AFRICA

The Middle East & North Africa (MENA) includes[167]:

Algeria	Jordon	Qatar
Bahrain	Kuwait	Saudi Arabia
Djibouti	Lebanon	Syria
Egypt	Libya	Tunisia
Iran	Malta	United Arab Emirates
Iraq	Morocco	West Bank & Gaza
Israel	Oman	Yemen

According to the United Nations, the MENA region population will grow from 300 million (2007) to 600 million in 2050. Currently this region holds 5% of the global population but only 1% of the global freshwater resource; therefore increasing the availability of fresh water is vital for survival. In parallel with population growth, the economy is projected to grow to a level that is similar to the GDP per capita in Europe by 2050. To support this growth, the electricity sector will require an exponential increase in generation capacity.

Reduced water demand through improved management and water efficiency programmes will partially alleviate the strain on water resources. However by 2050 the industrial, municipal and agricultural fresh water deficit is expected to be 150 billion m^3 per year. Egypt, Saudi Arabia, Yemen and Syria are expected to experience the worst effects. It is therefore essential that these nations begin to increase the production capabilities from conventional and renewable desalination plant while also improving water management systems in order to secure freshwater for the future[168].

Poverty and inequality is widespread throughout the MENA region. There are noticeable divides between urban and rural areas; modern, progressive societal sections and more traditional sections. Increases in food prices have affected the entire region. Considering 20% of the population live on less than USD$2.00 per day, substantial food subsidies have been enacted in order to prevent the occurrence of widespread hunger[169].

1.1 MENA Financial Markets

Like the rest of the world, the MENA region has suffered from the 2008/09 economic downturn. The effects of the global recession differed from country to country depending on the composition of each economy. The Cooperation Council for the Arab States of the Gulf (GCC) countries and Yemen

167 http://web.worldbank.org/

168 Trieb, F & Hani El Norkraschy, I (2008) Concentrating Solar Power for Seawater Desalination, AQUA-CSP Project, German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). http://www.dlr.de/tt/desktopdefault.aspx/tabid-3525/5497_read-6611/

169 World Bank (Sep 09) MENA Regional Brief, http://web.worldbank.org

were the worst effected due to an over reliance on oil revenues. In 2007/08 oil prices peaked at USD$140 a barrel, this caused an increase in government spending which was quickly reversed a year later when prices dropped.

In previous years all MENA economies were experiencing growth but now only economies that rely on the services sector have remained unaffected. However, some oil rich nations have weathered the storm by relying on previous earnings. Oil accounts for more than half on the GDP in: Algeria, Bahrain, Libya, Syria, Oman, Qatar, UAE and Saudi. At some point, these oil dependent nations will need to diversify their economies and begin to exploit renewable energy resources to insure long term energy security and to provide for a sustainable future.

The floundering financial markets in the UAE have seen a property crash and billions in loans still remain outstanding. This has led to a loss of confidence in investments across the gulf. Coupled with this, it is difficult for foreign investors to obtain objective information on the Middle Eastern markets.

Countries like Syria and Yemen are less impacted by the whims of the financial markets. Syria has a closed economy and Yemen only recently opened the nation’s first stock exchange. Economies such as Egypt, Israel, Morocco and Tunisia are heavily reliant on tourism, exports and international trade. These sectors have also experienced a drop; however they are expected to improve during 2010. Israel is one of the few MENA nations that have a thriving technology sector and a strong economy that is supported by US debt. In Jordon, growth has been stable over five years and their structural reforms, trade liberalisation and privatisation initiatives have seen it lead the region’s economic recovery.

In Iraq, Lebanon and Palestine there are issues of security. Iraq’s oil reserves are large and future exploitation is expected to transform the nation’s economy. The Lebanese service sector accounts for 66% of the total economy, although like many MENA states, they heavily subsidise the electricity sector. The Doha Agreement was signed between conflicting political parties in 2008, this has greatly stabilised Lebanon.

In Palestine the economy is subject to the peace process with Israel. The West Bank has improved slightly but Gaza still remains unstable. The unemployment rate in Gaza is 40.6% while the West Bank has 19% unemployment. Palestine has been supported by international grants and this is expected to continue despite the global economic condition. The GCC countries are capable of fiscal and structural reform required to improve their economies, however non oil producing nations with large populations often rely on foreign development loans[170].

170 Global Investment House (Jan 2010) MENA Economic Report, http://www.menafn.com/updates/research_center/Regional/Economic/gih070110ee.pdf

1.2 Political System

Countries that moving towards democratisation include: Morocco, Jordan, Kuwait and Bahrain. In other oil rich countries the political system is intrinsically linked to the economy such as Qatar, the UAE and Oman. Other countries either have a monarchy or a single party system as found in: Saudi Arabia, Syria, Algeria, Yemen, Libya, Egypt and Tunisia.

Iraq, Palestine and Lebanon have the most international influence on their regimes due to a history of instability. Israel has a democratic, western regime and is isolated from its neighbours in terms of common ground. In terms of implementing renewable energy desalination projects, developers must understand the practice of these regimes, there is some common ground with Europe on trade and financial markets but institutional organisation is quite different and developers should generally be mindful of the differences[171].

The MENA region contains the world's leading oil producing nations whom have accumulated an incredible wealth over the years. However, oil reserves are running out and global commitments to reducing greenhouse gas emissions mean that the region must begin to implement renewable energy as a long term solution. The region has a vast solar and wind energy resource that is waiting for investment and development. Although the Kyoto protocol has been ratified by many MENA states, if emission commitments were actually enforced it is unlikely that such an oil dependant region would comply[172].

2. MIDDLE EASTERN AND NORTH AFRICAN ENERGY SECTOR

Due to population and industry growth, the power sector in MENA has a demand that is growing at 5-7% annually. To meet this increasing demand; new power plant, increased efficiency, improved transmission systems and new energy sources are required[173].

Eight MENA countries: Algeria, Iran, Iraq, Kuwait, Libya, Qatar, Saudi Arabia, UAE are part of the Organization of the Petroleum Exporting Countries (OPEC)[174]. The Middle East holds 60% of the world proven oil reserves and 40% of the proven gas reserves[175] . It is this sector that has formed the nucleus of the Middle Eastern economy[176]. Consequently oil production and investment in the sector will continue throughout the region. In the future, oil exports from the Middle East are projected to decline but to grow as a percentage of global oil consumption - from 20% in 1990 to more than 25%

171 The Arab Reform Initiative (2008) Reform in the Arab World, The Palestinian Center for Policy and Survey Research, www.arab-reform.net

172 MENA Renewable Energy Conference (Nov 2009) Summary, http://www.fleminggulf.com/conferences/energy/mena-renewable-energy-2009-1#key_top

173 MENA Power (2010) MENA POWER 2010: A Middle East and North Africa Technology and Projects Forum, http://www.trademeetings.com/ssMeetingDetails.asp?meetingId=214

174 http://www.opec.org

175 AME Info (Jan 2010) Can the GCC become a global model of sustainability? http://www.ameinfo.com/221330.html

176 Oil and Gas Journal (Jan 2009), MENA POWER (http://www.eia.doe.gov/emeu/international/reserves.html

in 2025 and 33% in 2100. Total energy exports from the Middle East will double between 1990 and 2050, before declining back to their 1990 level by the year 2100. The MENA is also expected to increase its exports of natural gas and hydrogen derived from natural gas through solar electrolysis[177].

2.1 MENA Electricity generation

The MENA region has 146 GW of installed electrical capacity, a further 120GW of new capacity and 30 GW of replacement capacity will be required from 2005-2020 [178]. The MENA electricity utilities are lacking in finance, electricity is heavily subsidised in most countries and as a result this has lead to inefficient energy use. Electricity bills are often unpaid in some MENA countries; almost half the electricity consumption was unpaid or illegally connected in 2005. There is a downward spiral where by the underperformance of utilities is caused by low tariffs, unpaid bills and illegal connections which means revenues are too low to reinvest in the service. Most MENA states have tended to follow economic protectionist policies in which the economy, power, and water sectors are tied closely to government and there is a predominance of government ownership and involvement in the power sector.

In recent years, Independent Power Producers (IPPs) have been successfully encouraged through incentive programmes but there is still room for more private electricity producers. The UAE have made progress towards privatisation with the creation of new power sector and water companies. The Supreme Economic Council in Saudi Arabia turned the Saudi Electricity Company (SEC) into a holding company in 2008 with plans to privatise three quarters of the company[179].However, securing future capacity in a changing global market has led to the realisation that regulatory changes will have to take place in order to liberalise markets to both foreign and private power producers. Currently, wealthier MENA nations are offering scenarios based on power purchase agreements, equity from developers with government, utilities becoming financial partners and loans from private, local, and international finance institutions to encourage IPPs.

The current challenge in the MENA region is diversifying the energy mix beyond oil as a sizable proportion of the generation capacity is nearing the end of its lifespan and capacity demands are rising. The high power demand matches the high water demand and much work will have to be done to stabilise the resources of both[180].

177 Intergovernmental Panel on Climate Change (2001) The Regional Impacts of Climate Change Chapter 7: Middle East and Arid Asia, http://www.grida.no/publications/other/ipcc_sr/?src=/climate/ipcc/regional/153.htm

178 MENA Report (Mar 2010) A new source of power, the potential for renewable energy in the MENA region, http://www.menareport.com/en/business/262673

179 AME Info (Jun 2008) Saudi Power sector set for huge expansion, http://www.ameinfo.com/160931.html

180 Khatib, H (Sep 2005) Middle East Economic Survey, MENA Electrical Power Sector: Challenges And Opportunities, http://www.mees.com/postedarticles/oped/v48n39-5OD02.htm

2.2 MENA Electricity Grid

The MENA region is large and sparsely populated due large desert expanses. This makes regional power networks expensive and, in some cases, unpractical therefore many communities exist off the grid. The opportunity for off-grid renewable energy developments is therefore very high[181].

The Israeli Comet project is a good example: solar and wind generators are now providing electricity to the Palestinian Bedouins of Susiya, in the south Herbron hills. The project, funded by the Swiss Olive Oil Foundation, Comet-ME, and two Israeli physicists has been successful in helping ten Palestinian families receive light and power[182]. The Seven Countries Interconnection Project (SCIP), which interconnects the grids of Libya, Egypt, Jordan, Syria, Iraq, Turkey and Lebanon was launched at the beginning of the last decade. It has interconnected these countries with one or more Alternating Current (AC) lines. Further interconnection is planned and a ministerial meeting on a draft electricity grid plan took place recently in Beirut to aid cooperation and coordination on strengthening the electricity networks.

The multibillion-dollar Gulf States Cooperation Council (GCC) power grid project started in 2004 and is nearing completion. The project involves constructing transmission lines to link Saudi Arabia, Qatar, Bahrain, Kuwait, Oman and the United Arab Emirates. It is expected that this network will install 100,000MW of extra generating capacity over the next ten years. The grid project aims to supply adequate power, even in an emergency situation, and to reduce the cost of power generation to all six states. The first phase of the project, which links Saudi Arabia, Qatar, Bahrain and Kuwait, was completed in the first quarter of 2009. The project, with a total investment of USD$1.6 billion, will further connect the United Arab Emirates (UAE) and Oman in 2011[183].

Improved electricity networks will help lessen the reliance on diesel generators, improve reliability and help bring other power sources on line such as nuclear, hydro and renewables. This will help the region diversify their energy mix and improve the economy. The GCC countries hope this interconnected network will help encourage IPPs to connect to the network, establish competition, improve distribution to customers and eventually a regional power pool could be formed. The power sector is being reformed and privatised in most GCC countries which will help improve economic development and cooperation in the MENA region[184].

Conventional AC lines are not capable of transferring electricity long distances. However the EU-MENA DESERTEC project aims to connect the MENA region to the EU via High Voltage Direct Current

181 Khatib, H (Sep 2005) Middle East Economic Survey, MENA Electrical Power Sector: Challenges And Opportunities, http://www.mees.com/postedarticles/oped/v48n39-5OD02.htm

182 Mossel, Y (Sep 2009) Off the Grid in the Middle East, http://www.nhpr.org/node/27001

183 A1 Saudi Arabia (Dec 2009) Gulf countires set to form unified power grid by 2011, http://www.a1saudiarabia.com/Gulf-countries-set-to-form-unified-power-grid-by-2011/

184 Al-Asaad, h, Al-Mohaisen, et al (2007) GCC Power Grid: Transforming the GCC Power Sector into a Major Energy Trading Market, http://www.gccia.com.sa/articles/Paper-Cigre.pdf

(HVDC) lines for a Trans-European Electricity Grid. This ambitious project consists of ABB, the Deutsche Bank, E ON and the Club of Rome among others. It will require GBP£550 billion investment and MENA state support for renewables. It aims to supply 15% of Europe's energy requirements by 2050 through the construction of HVDC lines that connect renewable solar and wind plant across MENA to Europe[185]. Solar and Wind energy is considered intermittent energy sources so an interconnected network should incorporate conventional power generation. Alternatively, CSP plant could store and deliver power at night while smart grids could assist in managing power throughout the day[186].

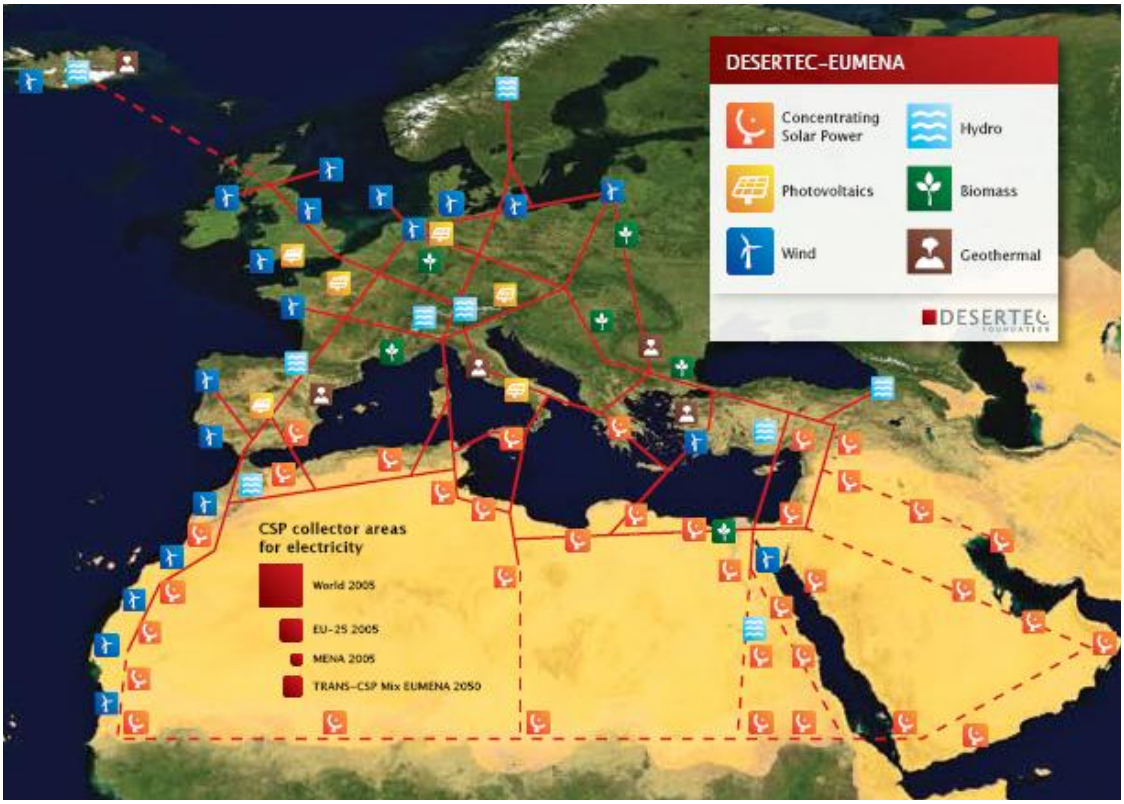


Figure 1: The DESERTEC-EUMENA Project

3. MIDDLE EASTERN AND NORTH AFRICAN WATER RESOURCE & MANAGEMENT

Water is viewed as an extremely important resource in the MENA region and crucial to economic development, poverty reduction, health and regional partnerships. MENA is the most water scarce region in the world. Urbanisation, rising population and increased living standards are increasing the resource constraint. Mismanagement of the resource and urban water supplies across the region are

185 www.desertec.org.

186 Mena Report (Mar 2010) New source of power, The Potential for Renewable Energy in the MENA Region, http://www.menareport.com/en/business/262673

further impacting the water reserves. The majority of countries in MENA, with the exception of Iran, Iraq and Syria, consume more fresh water than can be renewed on an annual basis.

Water is lost through leaking pipe networks, illegal connections and inadequate water metering systems – historically, water infrastructure has not received the attention it deserves. The loss of water in MENA varies between 15% in wealthier nations, such as Dubai, to 60% in less developed nations, such as Syria. Some disadvantaged areas only receive water for a few hours a day and are charged tariffs that are insufficient to support essential maintenance.

Over the past forty years, water infrastructure construction has included building dams, wells, pipelines, seawater desalination plant and wastewater treatment plant. Iran has a large number of dams, as does Syria, therefore hydroelectric power is a priority. In the north and eastern parts of the Middle East, dams have been built on the Tigris, Euphrates and Karun rivers but these dams just retain hydro-power during the rainy season in winter. Wells have been used historically by nomadic tribes for centuries and currently some rural communities rely entirely on well groundwater. However, these resources have been heavily exploited and a reduction in rainfall has led to a decrease in replenishment. As a result, this resource is becoming unreliable. A portion of the groundwater is also contaminated with salt, and in Jordon, radium was found in the Disi Aquifer[187].

Wastewater use for agriculture is common throughout MENA. Examples of efficient wastewater re-use can be found in Israel and Tunisia. However, disorganised management has led to untreated wastewater use in Jordon, Morocco, Algeria, the West Bank, Gaza, Syria and Yemen. In these nations, wastewater plants have had a history of improper management, serious health hazards and environmental disruption[188]. The Abu Dhabi Water & Electricity Authority in the UAE has recently contracted to construct two wastewater treatment plant in Abu Dhabi and Al Ain totalling approximately USD$91 million. There are numerous other wastewater treatment projects throughout the Gulf accounting for billions of dollars in investment. [189]

Climate change will depress agriculture yields in MENA by 11% by 2050. The region relies heavily on water for agriculture which comprises 85% of its water use so combating the continued drying of the land mass will be a priority[190]. The climate will become drier and hotter with less rainfall and increased droughts. Coastal flooding will increase in North Africa as sea levels rise up to 0.3 metres by 2050. Water shortages will be experienced by 80-100 million people before2025. Air quality is likely to reduce due to water scarcity which will ultimately affect public health. The impact of climate change on social, economic and environmental life is expected to be worse in MENA than the rest of

187 Tschanz, T (Aug 2009) Geographic Focu-Middle East: Overview of water related infrastructure projects, www.workingwithwater.net
188 World Bank (2008) Urban Water & Sanitation in MENA, http://web.worldbank.org/
189 Hunter, N (Aug 2009) Geographic focus – Middle East: Providing water and water infrastructure to the desert, http://www.workingwithwater.net/
190 World Bank (2010) World Development Report, Development and Climate Change, http://siteresources.worldbank.org

the world. Low lying coastal areas such as Tunisia, Qatar, Libya, UAE, Kuwait, and particularly Egypt are the most at risk to climate change[191].

3.1 WATER LEGISLATION

Due to recent infrastructure investments, water supply has increased to allow 75% of the MENA population access to clean water and improved sanitation. Large sums of investment have been allocated for water storage systems and agricultural irrigation. MENA already leads the world in desalination technology but more work is required to improve regulation and policy. However, the public sector is often overstaffed, underpaid and mismanaged, little public participation is found in the region, and hence water could be managed more effectively[192].

Like the electrical service, private water utilities are struggling to perform due to an unreasonable subsidisation of tariffs in the public sector. Only two countries in the region have private water utilities that can cover their operational and management costs. In MENA public spending on water accounts for 1-5% of the GDP but these investments have not been cohesive. For example dams have been built but with no irrigation infrastructure to transport stored water to farm land. Cleary, integrated water management initiatives combined with investment are essential to improve water access and sustainability across the region.

Further legislation is required to protect and secure the following: over use of ground water, pipeline maintenance, increase wastewater recycling, balance tariff subsidies (to assist the disadvantaged, but encourage conservation and better management), public education on water conservation and address the environmental issues associated with conventionally powered desalination plant. Many of these issues are being addressed with billions of dollars of investment; however, more legislation is required to improve water management and to secure sustainable development. The role of the public sector in the water supply also needs to be redefined in order to create a more competitive, efficient sector[193].

191 World Bank (2008) Adaptation to Climate Change in the Middle East and North Africa Region, http://web.worldbank.org

192 Transparency International (2009) Africa and the Middle East :Transparency International's Corruption Perceptions Index (CPI), http://www.transparency.org

193 World Bank (2008) Urban Water & Sanitation in MENA, http://web.worldbank.org/

4. MIDDLE EASTERN AND NORTH AFRICAN FUNDING & INVESTMENT

"If I were you, I would stop trying to make Saudi Arabia the oil capital of the world and make Saudi Arabia the energy capital of the world. You should take your cash right now and go out and buy half the solar capacity in the whole world and you should start at the equator. All the way around the equator and go north and south until you put solar power everywhere the weather will tolerate it. You will save the planet and get richer."

Bill Clinton, speech in Saudi Arabia in January 2006 to 400 business people from the Persian Gulf[194].

The Saudi Arabians plan to invest USD$170 billion in the energy sector over the next five years, requiring private sector investment to satisfy water and electricity demands for the Kingdom[195]. Of this investment, USD$90 billion will come from Saudi Aramco (National Oil company) and will primarily be invested in oil production. Despite Bill Clinton's suggestion, the head of Saudi Aramco, Khalid Al-Faleh does not perceive investment in renewable energy to be the most suitable option at this stage. The world demand for oil is on the increase therefore investment in oil production is more important[196]. This opinion is mirrored across the oil producing MENA nations where renewables are underfunded and fossil fuels are subsidised[197].

The World Bank plans to invest USD$5.5 billion in solar energy projects in the MENA region through the Clean Energy Fund (CTF) in order to increase the development rate of renewables. Private investors are also being attracted to the market because export revenue is promising[198]. There have recently been significant private sector investments in renewable projects; Solar World has founded a joint venture with Qatar Solar Technologies for a polysilicon facility funded by the Qatar Development Bank and Qatar Solar Technologies who will invest USD$500 million in the construction of the facility[199]. The Masdar green energy firm in Abu Dhabi also plans to invest USD$15 billion in renewable energy projects including the Masdar carbon neutral city[200].

Governments in the MENA region fund and guarantee almost all power projects, particularly in countries where no restructuring and privatisation of the power sector has taken place. These funds are provided from loans provided by international development banks such as the World Bank and the Islamic Development Bank. The total required investment to meet electricity demand in MENA is

194 Global Energy Network Institute (Oct 2007) Renewable Energy Potential of the Middle East, North Africa vs.The Nuclear Development Option, http://www.geni.org/globalenergy/research/middle-east-energy-alternatives/MENA-renewable-vs-nuclear.pdf

195 AME Info (Jun 2008) Saudi Power sector set for huge expansion, http://www.ameinfo.com/160931.html

196 AME Info (Mar 2010) Saudi Arabia to spend $170bn on Energy Projects, http://www.ameinfo.com/228104.html

197 The Grid (Mar 2010) Reports finds MENA region lagging on Renewable Power, http://blogs.thenational.ae/the_grid/2010/03/the-mena-region-offers-45.html

198 Smithson, T (Mar 2010) The Grass is Greener over in MENA, http://www.renewableenergyworld.com

199 Renewable Energy World (Mar 2010) SolarWolrd Jumps in MENA Solar Market, Opportunities to Grow in 2010, www.renewableenergyworld.com

200 Arabian Bussiness (Apr 2010) Arab world must push harder for renewable energy, www.arabianbusiness.com

USD$225bn (2005), with an average investment of USD$14 billion a year required to ensure adequate capacity by 2012.

According to a long-term perspective, the Gulf region is expected to invest more than USD$100 billion to meet its growing power demand, which is expected to rise to 116,000MW by 2020. In the short term, total investments in the GCC power sector will be approximately USD$46.4 billion to provide for expansion of existing power plant and establishing new projects that will add 37,000MW to their current capacity by 2010. A portion of this investment has been earmarked for solar and wind projects across the region but in general, most governments could go further to incentivise the renewable energy market and fund more projects.

MENA governments have invested heavily in water over the past twenty years and they are aware that water plant construction must be coupled with infrastructural improvement and more exploitation of renewable resources. The World Bank has heavily funded the region's water development and they are eager to see more private sector participation to improve performance. The World Bank has supported management contracts in the West Bank, the Gaza Strip and Jordan. It also plans to support management contracts and leases in Algeria, Yemen and in other countries.[201]. The World Bank provided the Republic of Yemen with USD$90 million in support of a water sector programme and USD$25 million to aid a rural energy project focused on solar energy. The Bank financed new water projects totalling USD$229.5 million in 2008 and USD$123 million in 2009[202].

The MENA region will invest USD$61.2 billion in its power and water sectors between 2007 and 2011. Iran, Saudi Arabia, UAE, Egypt and Kuwait account for 72% of this required investment. Government owned utilities will continue to play the key investment role as only 40% of the power requirement will be funded by the private sector[203]. The MENA Infrastructure Fund, Dubai, has been established with USD$500 million of private equity to act as a regional investor in infrastructure projects across the middle east and is supported by DICAM, HSBC Bank Middle East and Waha Capital[204].

4.1 RENEWABLE LEGISLATION

At a recent renewable energy conference in MENA, environmental experts were critical of the lack of momentum towards renewables considering carbon dioxide emissions doubled between 1990 and 2003. Kuwait, the UAE and Qatar are the largest greenhouse gas emitters per capita. The main reason behind the slow deployment of renewables is lack of renewable energy policy and fiscal support. However, this is not true of all MENA states, in the eastern Mediterranean countries such

201 World Bank (2008) Urban Water & Sanitation in MENA, http://web.worldbank.org/
202 World Bank (Sep 09) MENA Regional Brief, http://web.worldbank.org
203 Zawya (Mar 2007) MENA region to invest $ 61.2 bn in power and water till 2011, www.zawya.com / Dow Jones Newswires
204 http://steelguru.com/news/index/2009/06/02/OTY2Nzc%3D/MENA_Infrastructure_Fund_acquires_GDF_Suez_stake_in_Manah_power_project.html

as Israel, Palestine, Lebanon, Jordon, Morocco and Algeria are vulnerable to climate change but do not rely on fossil fuels to fund their economies. As a result the most promising pilot projects and policies are occurring in these countries[205].

The Institute for Renewable Energy Policy (IREP) aims to develop Israel as a world leader in this field and states that Israel is 'strategically motivated to release itself from its dependence on oil from the Middle East[206].' There has been a plethora of renewable energy conferences in the MENA region over the past few years. The MENA Renewable Summit 2010 will take place in May in Sharm El Sheikh, Egypt. The summit aims to engage key actors, investors and renewable developers across the region.

Several MENA states have adopted renewable energy initiatives and targets but political will and investment in oil rich nations is largely based on oil production carrying on as usual. Egypt is committed to 20% renewables by 2020. The Egyptian National Renewable Energy Authority are planning to host a 3,000MW wind farm as they aim to have 12% of their total electricity capacity coming from wind.

Algeria has a target of 6% renewables by 2015 and 10% by 2027. Algeria's government owned power company will spend USD$100 million on a solar panel factory that will have an annual production of 50 MW of solar panels before 2013. Tunisia has drafted the Tunisian Solar plan which will implement 40 projects between now and 2016. This will require an investment of USD$2 billion and a number of public private partnership agreements. The UAE plans to generate 7% of its energy requirements from renewable sources by 2020. Expectations are for the UAE to be producing 400MW from new solar and wind projects by 2015. Jordan has a goal of producing 90% of its own energy by 2020, 1200MW of which will come from renewables.[207]

Galal Osman, a solar expert at the Arab Solar academy, is doubtful of the reality in achieving these targets. One of the barriers is the expense of implementing renewables compared to the technologically established oil industry of which most nations still have reserves, that will continue to supply the world until at least 2100. However, climate change and environmental commitments will maintain pressure on these policies. In addition, the growing challenge of depleting fossil fuels, rising oil prices and growing demand means the MENA region will have to begin implementing renewables[208]. Knowledge exchange has been hampered by cultural, language and political differences between the west and between countries in MENA.

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205 Mason, M (2009) Renewable Energy in the Middle East, http://www.springer.com/engineering/energy+technology/book/978-1-4020-9891-8

206 http://portal.idc.ac.il/EN/MAIN/RESEARCH/IREP/Pages/aboutus.aspx

207 MENA Renewables Summit (Dec 2010) MENA Renewables, http://africanbrains.org/mena_renewables.php

208 Arabian Bussiness (Apr 2010) Arab world must push harder for renewable energy, www.arabianbusiness.com

The University of Kassel and Cairo University have combined their expertise to create a Masters Programme in sustainable energy[209]. Other such institutions such as the Arab Solar Academy, the International Renewable Energy Agency (IRENA) established by the Abu Dhabi Future Energy Company (Masdar) and the Energy Park for Renewable R & D in Dubai are pioneering renewable energy in the region[210]. There are also EU-MENA collaborative institutions such as Sahara Wind, which is pursuing wind development in North Africa[211], and the Trans Mediterranean Renewable Energy Corporation (TREC) which was established in 2003 with support from the Prince of Jordan to develop HVDC lines from MENA to the EU[212].

Sustainable environmental practice is a relatively new concept in MENA. Due to an over reliance on oil there has been a reluctance to make this a priority issue; however, impressive commitments have recently been made. Masdar is a future city to be built on the outskirts of Abu Dhabi for 50,000 people powered entirely by renewable energy. The Energy City in Qatar is currently under construction, it aims to conduct R & D into transforming carbon resources into cleaner energy sources. These plans are symbolic but not an overarching example of policy across the region. Public education in energy efficiency is lacking, for example most urban houses rely on conventional air conditioning which consumes more than 50% of the peak power load in the Middle East[213].

The regulatory framework is still oil dominated. Subsidies for oil create a barrier to renewable energy development; private renewable initiatives in the power sector have not been encouraged. All governments in the region must develop regulatory regimes that open the electricity market to alternative energy sources and attract foreign investment. Few MENA countries have considered privatising their distribution sectors, despite the need for infrastructural improvement and investment[214]. Interregional cooperation, institutional collaborative decision making, knowledge transfer, R & D and concrete policy are all required to realise MENA's renewable energy potential. There is no clear remit for renewable energy policy, it would be prudent for countries to establish specific departments for developing regulation that will define the potential and set targets for renewable power and water generation[215].

209 ReMena (2009) Intercultural Master Programme for Renewable Energies, http://www.uni-kassel.de/remena/index.php/10/home

210 http://www.masdaruae.com/

211 http://www.saharawind.com

212 http://www.desertec.org/

213 AME Info (Jan 2010) Can the GCC become a global model of sustainability? http://www.ameinfo.com/221330.html

214 Khatib, H (Sep 2005) Middle East Economic Survey, MENA Electrical Power Sector: Challenges And Opportunities, http://www.mees.com/postedarticles/oped/v48n39-5OD02.htm

215 Mena Report (Mar 2010) New source of power, The Potential for Renewable Energy in the MENA Region, http://www.menareport.com/en/business/262673

5. MIDDLE EASTERN AND NORTH AFRICAN RENEWABLE ENERGY RESOURCES

The MENA region could potentially be the biggest renewable energy supplier in the world. It is claimed that the region has 45% of the world's total solar energy potential and could generate more than three times the world's current power demand[216] (although this claim is unsubstantiated, it is certain that the region contains a significant solar energy potential, which is currently under exploited). Renewable energy will reduce dependence on fossil fuels for electricity generation meaning more oil would be available for export. Developing the region's renewable energy potential would mitigate local climate change and air quality issues but also contribute to global environmental efforts. An expansion into alternative energy would bring economic diversification and employment to the region where oil contributes 47% of the combined GDP but only employs 1% of the workforce.

A summary of available renewable energy resources is displayed below:

- MENA has an excellent inland wind resource.
- The geothermal potential in MENA has not yet been assessed but is expected to be limited.
- Energy from biomass is unlikely as the water required to grow biomass crops is required for agriculture and population growth.
- Wave and Tidal energy is also limited.

Solar power has a large potential and it is predicted that the solar market will grow substantially over the next ten years. Although this region has been slow to adopt renewables, news articles indicate that governments and international enterprises are now moving to capitalise on the abundant solar resource; 9,000 MW of concentrated solar power (CSP) is already planned to be deployed throughout the region by 2020.

It remains unclear how regulations and frameworks will come into place to support the renewables industry[217]. North African countries like Morocco and Tunisia are especially eager to install renewable energy systems since they import all of the fuel used to generate their electricity[218]. The technical challenge for solar power in MENA is combating desert conditions to keep the panels functioning. However some companies such as Abenoa, Acciona and Nur Energie will provide case studies of their own experiences at the MENASOL Conference 2010[219]. In addition, solar has the advantage of using relatively small areas of land, which is often un-used and infertile. Improvement of living conditions in rural areas, through access to power and job creation may also reduce net

216 A New Source of Power; The Potential for Renewable Energy in the MENA Region by Ibrahim El-Husseini, Dr. Walid Fayad, Tarek El Sayed and Daniel Zywietz (March 2010, Booz & Co.)

217 New Solar Today (Feb 2010) North Africa and Middle East Solar Opportunities booming in 2010, www.newsolartoday.com

218 Mena Report (Mar 2010) New source of power, The Potential for Renewable Energy in the MENA Region, http://www.menareport.com/en/business/262673

219 New Solar Today (Mar 2010) Solar in MENA: 9, 000 MW of Concentrated Solar Power Capacity planned by 2020, http://www.renewableenergyworld.com

migration to urban areas[220]. Below are examples of renewable energy developments in MENA currently underway:

Algeria

A 150MW hybrid solar-gas power station at Hassi R'Mel is underway; it is expected to contribute 5% of the national generating capacity by 2015. Algeria has a large, uninhabited southern desert with an average wind speed of 6.5 – 7.5 m/s. One solar thermal plant is under construction, and two more Integrated Solar Combine Cycle (ISCC) plant, each with an output of 400 MW and 70 MW, will be developed between 2010 and 2015.

Egypt

Zaafarana, in the Suez gulf has provided land for wind farm developments since 2001 and further bids have been invited for a 250MW farm in the area. Further south, the Egyptian National Renewable Energy Authority (NREA) plans to host a 3,000 MW wind farm. Solar potential is also large and estimated at 2,000kWh/m² per year. A 140MW solar thermal hybrid power plant at Kuraymat, south of Cairo, is being implemented and according to NREA it will reduce CO_2 emissions by 38,000 tonnes/year.

Iran

Iran will complete a solar thermal electric power plant in Yazd in 2010. It will ensure uninterrupted power during peak demand periods, cloudy days or early evenings with the aid of an auxiliary natural gas-fired heater. Iran is also developing capacity for solar-thermal plant with a 250 kW plant in Shiraz.

Israel

Over 700,000 households in Israel have solar water heaters. The Ashalim plant is slated to be built in Israel's Western Negev desert over the next few years and will consist of 2 solar thermal power stations, each with a capacity of about 120 MW, with a maximum installed capacity of about 250 MW. The estimated cost of the project is US $750 million.

Jordan

Is searching for wind developers to build and operate commercial farms across the country. They also plan to introduce private sector incentives, tax exemptions and cost subsidies to aid renewable projects. The JOAN1 project is expected to enter operation in 2013 and will be the largest CSP

220 Global Energy Network Institute (Oct 2007) Renewable Energy Potential of the Middle East, North Africa vs.The Nuclear Development Option, http://www.geni.org/globalenergy/research/middle-east-energy-alternatives/MENA-renewable-vs-nuclear.pdf

project in the world using direct solar steam generation. They have employed photovoltaic cell systems for lighting in remote villages under the Jordanian Badia project for lighting Rawdat Al-Bindan in Ruwaished district. The project was commissioned in October, 2002, as a pilot project for the development of rural areas.

Tunisia

The northern coastline has a 1,000MW wind potential. The government plans to develop three wind farms and aim to have 220MW of wind capacity by 2012.

Saudi Arabia

The first solar pilot plant (10MW) will be ready in 2011 and another 20MW solar plant is planned for the King Abdullah University of Science & Technology. Saudi's state owned energy company, Saudi Aramco plans to become a major contributor to solar power generation over the next 5-10 years. According to an interview with Reutuers, the Kingdom's minister for petroleum and mineral resources, Ali Al-Naimi said, "Saudi Arabia aspires to export as much solar energy in the future as it exports oil now."

UAE

The UAE forecasts suggest that by 2050 up to half of the UAE's required energy will come from renewable sources; of which solar is expected to compose a large percentage. Solar energy is also being used to power parking meters, offshore buoys, and water heating in hotels. The first photovoltaic solar-cell production line has recently been opened in the Fujairah Free Zone, with an investment of USD$2 billion.

Abu Dhabi has pioneered its world famous Masdar initiative, the largest clean energy development programme in the world with investments of more than USD$22 billion. Initiated in 2006, construction will continue into 2015. The project will employ a mixture of renewable energy sources; concentrated solar power, rooftop photovoltaic modules, wind farms around the city's perimeter and geothermal power.

The GCC Countries

Barhrain, Kuwait, Oman, Qatar and the other oil rich nations are still investing in oil but the International Solar Society predicts that these countries could successfully install as much as 5,000MW of wind and solar capacity by 2015. The GCC countries can draw from their Sovereign Wealth Funds (SWFs) to engage in long-term strategies for energy diversification[221] [222] [223].

221 Global Energy Network Institute (Oct 2007) Renewable Energy Potential of the Middle East, North Africa vs.The Nuclear Development Option, http://www.geni.org/globalenergy/research/middle-east-energy-alternatives/MENA-renewable-vs-nuclear.pdf

5.1 MARKET POTENTIAL

The MENA region has a fantastic solar energy potential. Using Concentrating Solar Thermal Power (CSP) plant for seawater desalination is a viable option. The solar resource in the MENA region is equivalent to 1.5 million barrels of crude oil per square kilometre per year (~2,400 kWh/m^2/year). According to Franz Trieb of the Institute of Technical Thermodynamics, Germany, each square kilometre would provide sufficient energy to desalinate approximately 165,000 m^3 of water per day.

Solar generation can provide both electrical power and power for desalination plant. The "coastal potential" for CSP is approximately 5,700 TWh/year[224]. The Institute for Technical Thermodynamics estimate that a rapid implementation of CSP could cease the non-sustainable use of water by 2030. Less than 1% of MENA's land mass would be required to provide solar power for the entire region. To achieve this, the political framework must adapt: dismantle subsidies for fossil fuels, encourage joint investments and cross border grid expansion with Mediterranean nations[225].

6. MIDDLE EASTERN AND NORTH AFRICAN DESALINATION

The Middle East is the largest desalination market in the world. Saudi Arabia relies on seawater desalination for 50% of its water supply and has over 30 operating desalination plant. The United Arab Emirates which relies on 70% desalinated water to supply the country and Kuwait. It is estimated that the region requires a 6% increase per year of desalinated seawater to sustain their water supplies.

The majority of desalination plant use thermal desalination technologies and large quantities of fossil fuel are required for the distillation process. More worryingly, the hot wastewater is often discharged directly into the gulf and has increased the temperature of the seawater in the local marine environment. Discharges of high concentration brine water, chlorine and copper are also prevalent in gulf waters[226].

Desalination requires large amounts of energy and the utilisation of renewable resources is feasible since MENA is a water scarce region largely due to the abundance of solar radiation[227]. Seawater desalination is located on the coast and pumped inland via transmission pipelines to where it is required. Saudi Arabia has 4,000 km of water pipelines and this network is under pressure due to

222 MENA Renewables Summit (Dec 2010) MENA Renewables, http://africanbrains.org/mena_renewables.php

223 New Solar Today (Feb 2010) North Africa and Middle East Solar Opportunities booming in 2010, www.newsolartoday.com

224 Trieb, F (2007) Concentrating Solar Power for Seawater Desalination, MENAREC, Syria

225 Trieb, F & Hani El Norkraschy, I (Concentrating Solar Power for Seawater Desalination, AQUA-CSP Project, German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). http://www.dlr.de/tt/desktopdefault.aspx/tabid-3525/5497_read-6611/

226 Tschanz, T (Aug 2009) Geographic Focu-Middle East: Overview of water related infrastructure projects, www.workingwithwater.net

227 Ha Qiblawey, H & Banat, F (Jan 2007) Solar thermal Desalination Techonologies, Desalination 220 (2008) 633–644http://www.solarthermalworld.org

increasing population and urbanisation. The pumping distances for other countries such as UAE, Qatar, Kuwait, Israel and Jordon is shorter but pipe leakages and management have been a barrier.

Current projects include a new pipeline in Saudi Arabia to supply the city of Taif near the Red Sea, and a tender for five new water pipelines in Kuwait between Mina Abdulla and West Funaitees. There are numerous other projects throughout the Gulf region, including widespread maintenance of existing pipelines to eliminate leakage that has been cited as a significant contributor to water shortages[228]. There is also a plethora of new desalination projects planned across the MENA region. Desalination technology has been incredibly important to meeting the water demand but its environmental impact in the region is now coming under scrutiny. The International Desalination Association (IDA) will meet in November this year to discuss these environmental issues.

Various small-scale renewable desalination projects have been conducted in the MENA region over the past twenty years including:

- A hybrid MSF-RO system driven by a dual purpose solar plant was installed in Kuwait which produces 25m^3 of water per day.
- Pilot projects for solar pond collectors have been carried out in Abu Dhabi with a 120m^3/day plant in 1985 and in Tunisia.
- In Saudi Arabia a PV-RO brackish water plant was installed and connected to a solar still with a production of 5m^3/day. The feed water of the solar still is the blow down of the RO unit (10m^3/day) in 1998.
- Wind powered brackish water plant was piloted in Jordan and shown to be cheaper than diesel engine brackish water systems.

These were all small-scale projects that have contributed to the general consensus that renewable desalination is a feasible option in the Middle East. The most popular combination is MEB with thermal collectors and RO with PV technology. Solar technology is best suited to remote, off-grid communities. The conclusion still seems to rest in academic circles and must be successfully communicated to the decision makers, who concentrate on large desalination plant to provide potable water to large populations[229].

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228 Hunter, N (Aug 2009) Geographic focus – Middle East: Providing water and water infrastructure to the desert, http://www.workingwithwater.net/

229 Kalogirou. S (Mar 2005) Seawater desalination using renewable energy sources, http://membrane.ustc.edu.cn

The MENA region has now initiated large scale renewable desalination projects. Saudi Arabia has started to build the first solar powered desalination plant[230]. IBM has entered into a joint venture with King Abdulaziz City for Science and Technology (KACST), the Kingdom's main research and development institute, to investigate the possibility of building a solar powered desalination plant in the city of Al Khafji in the northeast of the country. The plant would be powered by PV technology and would provide up to 30,000 m^3 of potable water a day to 100,000 people and is scheduled to be operational by the end of 2012[231].

Renewable desalination is recognised as a viable technology in the MENA region. Numerous small-scale projects have proven its feasibility however; investment continues to be channelled towards conventional desalination technology. International pressure on climate change and environmental issues are a motivating factor for renewable desalination projects. Renewable energy is crucial to diversifying the energy mix and securing adequate supply across the region.

6.1 MENA Desalination Projects

Major desalination projects in the MENA region include:

Shoaiba Barge Seawater RO plant is the largest in the world, producing 50,000 m^3/day using Dow Film Tec membrane elements which have helped speed up the production of treated water.

GE Water has a long history in the Middle East, first operating in the Saudi water sector in the 1930s. It has a base in Dubai and the company is involved in many desalination and wastewater plant across the region. GE Energy opened its second USD$10 million water technology centre in Saudi Arabia aimed at providing water solutions across the region.

Recent GE Energy projects include Marafiq, believed to be the world's largest independent water and power project with the capacity to produce more than 2.7 GW of power and 800,000 m^3/day of desalinated water. In partnership with the ConocoPhillips Water Sustainability Centre (WSC) in Qatar, GE Water is working to develop more efficient and cost-effective treatment technologies and will research and develop water solutions primarily for the petroleum and petrochemical sectors.

Ashkelon plant in Israel constructed, as a joint venture with IDE technologies, Veolia water and Dankner Ellern Infrastructure cost USD$250 million and supplies 320,000 cubic metres of water a day at £0.52/m3[232].

Desalination plants are continuing to be built across the region with large investments to be made in order to meet water demand. Saudi Arabia plans to invest USD$53 billion in this sector to meet

230 Global Energy Network Institute (Oct 2007) Renewable Energy Potential of the Middle East, North Africa vs.The Nuclear Development Option, http://www.geni.org/globalenergy/research/middle-east-energy-alternatives/MENA-renewable-vs-nuclear.pdf

231 Arabian Business (Apr 2010) Saudi eyes solar powered desalinatin plant, http://www.arabianbusiness.com/585567-saudi-eyes-solar-powered-desalination-plant

232 Unni, S (Oct 2009) Membrane technology: Qaulity water in unique location, www.workingwithwater.net

expected demand by 2020. The UAE has invested a total of USD$50 billion in power and desalination during the past 10 years and they plan to build three more desalination plant. Dubai has embarked on a mission to more than treble its desalinated water capacity over the next eight to 10 years. It will invest up to USD$20 billion in five power and water projects.

7. COUNTRY PROFILE: MOROCCO

7.1 Morocco: Overview

Morocco has recently initiated a national development programme which includes: democratisation and efforts to reduce poverty, construction of new cities near Rabat and Marrakech as well as a rural electrification programme that is scheduled to be completed by the end of 2010. Additionally, the construction of highways has tripled in the past ten years; tourism has grown from 4.2 million visitors in 2002 to more than double that figure in 2010 and a large sea port is currently under construction at Tangier.

The country currently imports 90% of its energy needs but there are plans to diversify the energy mix by generating their own electricity from hydropower, nuclear and renewable energy. Improving the water and energy resources are seen as essential to ensuring sustainable social and economic development. The Moroccan economy is primarily based on exports to the European Union which compose 66% of all foreign exports; however Morocco is not highly dependent on a single economic sector. The economy grew by 5.6% in 2008 but this growth slowed last year, however, the economy remains relatively buoyant compared to many nations.

Morocco has the third largest stock market in Africa after South Africa and Egypt[233]. Despite some excellent progress in poverty reduction and improved economy, Morocco is still vulnerable to climate change, low income levels, high youth unemployment and increasing pressure on water resources[234].

7.2 Morocco: The Energy Sector

Access to energy is seen as one of the main components to economic development via the Rural Electrification Program Global (PERG). Morocco imports 90% of its energy supplies due to little indigenous resources. Oil represents nearly 60% of all energy consumption and, in 2008, created USD$70 billion drain on finances. Clearly they aim to secure indigenous supplies to decrease this bill and reforms are being carried out in the energy sector towards liberalisation and development partnerships for oil and electricity. Services will be restructured to ensure cohesive planning for coordination and consolidation of funds for development projects.

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233 Global Investment House (Jan 2010) Morocco MENA Economic Report January 2010, http://www.menafn.com/updates/research_center/Regional/Economic/gih070110ee.pdf

234 World Bank (Sep 2009) Morocco: Country Brief, www.worldbank.org

Demand for power has grown at 8% year on year for the past five years. It is recognised that rigorous energy efficiency policies will be required. Electrical power consumption is 22TWh/year and is expected to rise to about 85TWh/year by 2020. A National Plan of Priority Actions in the electricity sector was developed in 2008 to restore the balance between supply and demand for 2008-2012. By 2020-2030 Morocco aims to possess nuclear power, solar power, wind and biomass as important contributors to the electricity mix, however, this is dependent on their technical feasibility[235].

7.3 Morocco: The Grid

The Global Rural Electrification Programme expired in 2008. It increased electrification in rural areas from 18% in 1995 to 95% in 2008. The programme will be replaced with a new rural electrification programme with an aim to increase electrification beyond domestic use to encourage rural economic development and profitable investment in electrical networks.

Since initiating the Global Rural Electrification Programme (PERG); 34,231 km of medium voltage lines, 88,565 km of low voltage and 17,073 electrical posts have been installed. This has been of major socio-economic benefit to rural areas, small businesses and industries have emerged as a result. Combined cycle gas power plant, pumping stations, wind farms and a natural gas pipeline from Europe has increased the nation's installed electrical capacity by 44% since 1999.

Under the Capital Master Plan 2002-2010 an additional 1024MW of generating capacity was added. The electrical interconnection with Spain contributes 16% of demand (2007). A North Africa/Middle East/European Power Pool will be completed in 2015. It will connect the grids of North Africa (Algeria, Egypt, Libya, Morocco, and Tunisia), Spain and the Middle East (Jordan, Syria, Turkey, and Iraq). The interconnection between Libya, Tunisia, Algeria and Morocco will be upgraded from 220 kV to 400 kV[236].

7.4 Morocco: Renewable Legislation

A New Energy Strategy has been developed to ensure future sustainable energy development in Morocco. Priority structural reforms have been identified to ensure security of supply, cost effective access to energy, diversifying sources, developing national energy sources and promoting energy efficiency. Ultimately, the aim is to reduce imports on petroleum products to 40% of the total energy mix by 2030. From 2009 to 2015, augmented capacity will be 6000MW and have the following contributions: coal fired power (45%), wind energy (22%), gas turbines to power (11%) and 7% is expected to come from solar thermal plant[237].

235 MEM (Oct 2008) Kingdom of Morocco, Ministry of Energy, Mines, Water and Enviroment, Key Achievments (1999-2009), www.mem.gov.ma

236 EIA (Dec 1999) A Snapshot of Africa's Electric Power Industry, http://www.eia.doe.gov/emeu/cabs/chapter5.html

237 MEM (Oct 2008) Kingdom of Morocco, Ministry of Energy, Mines, Water and Environment, Key Achievments (1999-2009), www.mem.gov.ma

The Moroccan target for renewables is 20% of the electricity capacity by 2012. This will require the deployment of 1,440MW of renewable energy. It is believed that 7,000MW of wind energy can be developed. In addition, there are plans to exploit solar water heating panels for households and a combination of photovoltaic and CSP plant to generate 1480MW of capacity. Plans have been developed to construct new dams and transfer stations for hydropower with a potential 1730MW installed capacity. The government is currently reviewing tariff structures under the National Plan of Action Priority (NPAP) to encourage new energy into the mix and to assist consumers with an appropriate pricing mechanism.

The DESERTEC consortium is encouraging Morocco to introduce FITs to bring other MENA states on board with their vision of Trans European – MENA grid.[238]. In January 2010, the Moroccan parliament approved the Moroccan National Programme for Development of Renewable Energies and Energy Efficiency (PNDEREE) aimed at raising the contribution of renewables[239]. Other draft bills include changing the remit of the Centre for Renewable Energy Development (CDER) to promote renewable energy, energy efficiency and integrate with the EU market to promote investment and production. According to Professor Abdul-Aziz Bennouna, the former head of the National Centre for Scientific and Technical Research, Morocco should also implement national programmes for skills training and R & D for renewable technologies in order to further encourage clean energy development[240].

In March this year Princess Lalla Hasna of Morocco addressed a delegation in Washington DC to announce the country's environmental commitment on sustainable development to mitigate climate change, water resources, agriculture and renewable energy[241]. The Ministry for Energy, Mines, Water and the Environment recognise that implementing renewable energy systems and improving the power mix will require cohesive organisation of service providers and regional areas, liberalisation of the distribution market and improved demand management[242].

7.5 Morocco: Renewable Resource and Development

Morocco has an excellent wind resource with average annual wind speeds of six metres per second (6m/s) in Northern Morocco and 7m/s along the Southern Atlantic Coast[243]. Morocco has been developing its wind power sector for a number of years. The Al Koudia Al Baida Wind Park (50.4 MW) was built in 2000 by a French-Danish consortium for ONE. The Abdelkhalik Torres (3.5MW) demonstration wind park was established at the same time with support from the German

238 AE Africa (Mar 2010) Morocco First on Desertec Minds, http://ae-africa.com/read_article.php?NID=1856

239 MENA Renewables Summit (Dec 2010) MENA Renewables, http://africanbrains.org/mena_renewables.php

240 DESERTEC (Feb 2009) Clean Power from Deserts: The DESERTEC Concept for Energy, Water and Climate Security, 4th Edition, www.desertec.org

241 AE Africa (Mar 2010) US Applauds Morocco's RE Efforts, http://ae-africa.com/read_article.php?NID=1897

242 MEM (2010) Directore of Elecricity and Renewable Energies (DEER) overview webpage, http://www.mem.gov.ma/Ministere/directions.htm#DEER

243 According to the Atlas Eolien (Morocco Wind Atlas).

government[244]. Morocco almost doubled its wind power generating capacity in 2009 to 260MW. A new wind farm near Tarfaya on the south-western coast is expected to produce 300MW by 2011.

A wind turbine density of 2.4 MW/km², distributed over the 2,000 kilometre coastline from Morocco to Mauritania would generate more than 1,000 TWh/year. This would be sufficient energy to supply the European Union with almost half of its annual energy demand (2,300 TWh)[245].

The solar resource in Morocco is excellent and could prove cheaper than Spain. According to DESERTEC, Morocco could supply Europe with clean energy in two decades. This consortium is eager to pursue renewable energy in Morocco as part of the wider EU-MENA DESERTEC plan. The DESERTEC group perceive solar desalination as a viable option for the country[246].

7.6 Morocco: The Water Sector

Water and sanitation services are provided by three main private companies in the largest cities; public municipal utilities provide 13 other cities; and a further 40 municipal utilities serve smaller towns. ONEP controls the bulk water supply and also distributes water to over 500 municipalities. ONEP produces 80% of the national drinking water and supplies 96% of the urban population. However, 20% of rural supply is unreliable and many households are not connected to water mains in urban areas.

The Directorate of Public Corporations and Privatization of the Ministry of Finance oversees the fiscal aspects of public utility operations. The Ministère de l'Energie, des mines, de l'eau et de l'environnement (MEMEE) (*Ministry of Energy, Mining, Water and Environment)* is responsible for water resource management and bulk water supply, while the Ministry of Interior supervises distribution and sanitation of the municipal utilities. Within the Ministry of Interior, the Direction de l'eau et de l'assainissement (DEA) (*Directorate for Water and Sanitation*) assists local governments with water and sanitation issues. In addition, they play an active role in planning, implementing, and supporting the operations of basic water infrastructure. Overall, the sector is characterised by a complex and fragmented institutional framework, which has hindered development[247].

7.7 Morocco: Access to Water

Present water availability is near 600m³ per capita annually, already significantly below the internationally accepted water stress limit of 1,000m³ [248]. The water sector has experienced

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244 African Wind Energy Association (2005) Wind Power Morocco, http://www.afriwea.org/en/projects.htm

245 MENA Renewables Summit (Dec 2010) MENA Renewables, http://africanbrains.org/mena_renewables.php

246 DESERTEC (Feb 2009) Clean Power from Deserts: The DESERTEC Concept for Energy, Water and Climate Security, 4th Edition, www.desertec.org

247 Association Marocaine de l'Eau Potable et de l'Assainissement, http://www.amepa-maroc.com/index.php

248 DESERTEC (Feb 2009) Clean Power from Deserts: The DESERTEC Concept for Energy, Water and Climate Security, 4th Edition, www.desertec.org

significant overhauls allowing over 90% of rural Moroccans to gain access to potable water compared to 50% in 2004.

Rainfall, however, has become scarcer and is unevenly distributed across the nation with most falling in the north of the country. Morocco has 16 billion m^3 of surface water and 4 billion m^3 of ground water. One hundred dams provide a storage capacity of 15 billion m^3. These dams are fed by seven river basins from the Atlas mountain source and there are proposals to exploit this basin resource further.

ONEP intends to construct 43 new wastewater plant, however wastewater use will not cover the nation's increasing water needs. Desalination is uncommon in Morocco but recently it has entered the government's agenda and further examination of the technology is ongoing. Water pollution is also a problem and groundwater has been over exploited particularly in the south to supply agricultural needs.

7.8 Morocco: Water legislation

The Water Law 1995 aimed to expand the focus from water supply to include water management initiatives such as promoting water efficiency, safeguarding resources from overuse and introducing integrated water management across the sector. Morocco, with the help of development loans from the World Bank and other funders, is on track to meet its Millennium Development Goals (MDGs). Now the emphasis is placed on developing alternative resource solutions such as desalination and water re-use, as these goals were not achieved under the 1995 Water Law[249].

The supply sector has received significant investment in the form of dams, irrigation systems and improved infrastructure. It is believed that it is now time to focus on diversifying the water mix and investing in integrated water management initiatives. In 2005 the National Water and Sanitation Programme (PAGER) aimed to treat 60% of wastewater, and the National Human Development Initiative aimed to connect the rural and urban disadvantaged to water networks. In 2004 PAGER received a UN public service award for its effort in relieving the women and children from carrying water long distances. Overall the programme has seen an increase in rural water supply from 14% in 1995 to 86% in 2009[250].

ONEP supplies one third of the rural population via standpipes, it is believed that more connections need to be made directly into homes. Especially since 11% of the population use the free standpipe, therefore no revenue is received from 11% of the nation's distributed water. Morocco's complex water tariff system includes some of the highest tariffs in the MENA region. In some areas, such as

249 World Bank (2009) Morocco- Water Sector Development, www.worldbank.org

250 World Resources Institute (2009) Water Resources and Freshwater Ecosystems: Country Profile: Morocco, http://earthtrends.wri.org/text/water-resources/country-profile-126.html

Casablanca, ONEP imposes a bulk tariff to private service providers equal to 5% of their income to pay for investments.

No specific framework exists in Morocco regarding wastewater re-use, however the Department of Energy, Mines Water and the Environment did conduct an initial study into wastewater in 2009. Since the late 1990s the water sector has been in a process of privatisation, although corruption has held back competition. The Marrakech utility began constructing a wastewater plant in 2009; however Agence Francaise Development (AFD) (*French Development Agency*) and the European Investment Bank withdrew their funding due to incomplete tenders[251].

Morocco has been drawn to seawater desalination as a source of water supply for consumers, industry and the mining sector. It also recognises the connection between water and power. The government plans to create a national public utility alliance between ONEP and ONE (Office National d'Electricite) (*National Office of Electricity*) called Office National d'Electricite et d'Eau potable (ONEE) (*National Office of Electricity and Potable Water*). ONEE will financially assist public utilities in charge of water supply, sanitation and electricity distribution in both urban and rural areas[252]. This combination should help the case for renewable desalination as water and energy will be under the same public utility's remit.

7.9 Morocco: Funding & Investment

In order to improve energy infrastructure, USD$22 billion in investment is required. Up to 50% of this sum will be used for improving power generation by implementing new technologies to exploit domestic resources to their full potential. Government investments in the electricity sector, including the Global Rural Electrification Programme cost USD$53billion between 1999 and 2008[253]. The Moroccan government has also approached the World Bank to invest in its energy sector. The tentative financing picture is USD$100 million from the International Bank for Reconstruction and Development Loans, USD$150 million from the Climate Investment Fund and a further USD$1billion from the Moroccan government. This will be used to promote development of the following areas: renewable energy (40%), conventional energy (30%), district heating and energy efficiency services (15%) and the transport sector (15%)[254].

In 2007 the World Bank gave Morocco USD$100million towards the water sector to support institutional reform, pipelines and inefficiencies. Prior to this, the International Bank for Reconstruction and Development gave Morocco over USD$10 million to develop their water sector

251 AuHorudhui (Nov 2005) Pager: de l'eau potable pour tous, http://www.aujourdhui.ma/entreprise-details40053.html

252 Global Water Intelligence (Jan 2009) Moroccan capital eyes greater reuse capacity, http://www.globalwaterintel.com/archive/10/1/general/moroccan-capital-eyes-greater-reuse-capacity.html

253 MEM (Oct 2008) Kingdom of Morocco, Ministry of Energy, Mines, Water and Environment, Key Achievements (1999-2009), www.mem.gov.ma

254 World Bank (2010) Morocco - Energy Development Fund Project, http://www-wds.worldbank.org

which allowed the nation to meet their Millennium Development Goals by supplying potable water and sanitation to the majority of the population.

From 2005 to 2009 public expenditure on urban and rural water supplies rose from 5% to 25% of total public expenditure[255]. Morocco has achieved many of its water and sanitation programme developments due to the help of foreign aid in the form of loans and grants. The following countries and organisations have provided billions of dollars in investment for water sector reform over the past ten years: the World Bank, US Aid, the African Development Bank, the EU and the European Investment Bank, the Japan Bank for International Cooperation, the Islamic Development Bank. Morocco also has key relationships with the governments of Germany, France and Italy, who have provided millions of dollars in funding over the years, and this is set to continue[256].

7.10 Morocco: Desalination

Morocco has a semi-arid climate and the country is rapidly experiencing a decrease in available water. Without implementing desalination techniques water scarcity will continue. Morocco has access to more than 3500km of coastline. Desalination has, however, been impeded by the fact that Morocco imports 95% of its energy requirements and such plant require a considerable amount of energy to operate. The Office National de l'Eau Potable (ONEP) (National Office of Potable Water) and the Cherifien Office of Phosphates (COP) have made considerable efforts to implement desalination plant in the south of country.

The current national production capacity from desalination is 30,000 m^3/day. ONEP operates the country's largest desalination plant in Laayoune. The Laayoune Seawater Reverse Osmosis Plant is conventionally powered and has a capacity of 7,000 m^3/day[257]. ONEP chose Agadir for its first privately financed desalination project in 2007[258]. The plant will be located on Morocco's Atlantic coast and will produce 45,000m^3/day of desalinated water[259].

The Secrétariat d'Etat chargé de l'Eau et de l'Environnement (SEEE) has recently completed a nationwide study on long-term desalination strategy. Although desalination has traditionally been confined to small-scale applications in Morocco, approximately 70,000m^3/day of new capacity is under planning and yet to be tendered. The study will also address how to approach the development of a large, new desalination plant in the Casablanca region, with a proposed capacity of around 685,000m^3/day.

255 World Bank (2009) Morocco- Water Sector Development, www.worldbank.org

256 Afrikaanse Ontwikkelingsbank (AfDB) (2007) Morocco: Water Sector Adjustment Programme (SAP), http://www.evd.nl/zoeken/showbouwsteen.asp?bstnum=52111&location=

257 Zidourhi, H (Oct 2005) Desalination in Morocco and presentation of design and operation of the Laayoune seawater reverse osmosis plant, Desalination, http://cat.inist.fr/?aModele=afficheN&cpsidt=826178

258 Global Water Intelligence (April 2007) Morocco gears up for first desalination PSP, Vol 8 (Issue 4), http://www.globalwaterintel.com

259 Global Water Intelligence (Mar 2009) Agadir desal project moves forward, Vol 10 (Issue 3)http://www.globalwaterintel.com

7.11 Morocco: Example Renewable Desalination Project

2005 Wind Powered Desalination in the Akfennhir Village

Location	Akefennhir, South Morocco on the Atlantic coast, about 100 km to the south of Tan-Tan city. Pilot project, overseen by ONEP.
Partners	Memorandum of Understanding between Italian Ministry for the Environment and Territory(IMET), Centre de Développement des Energies Renouvelables (CDER) and ONEP.
Value	€1,500,000
Funding	ONEP
Technology	RO desalination technology and wind turbines
Plant Power	Unknown
Status	Project completed. Project concluded that wind power was feasible as a form of desalination and should be grid-connected to ensure cost effectiveness[260].

260 MEDREC (2005) Morocco, Wind powered desalination in Akfennhir village, http://www.medrec.org/e

7.12 Morocco: Renewable energy desalination market potential

Morocco has a large potential for wind and solar desalination technologies, and thus far, some small-scale projects have demonstrated this potential. ONEP launched a project in the south of the country for a wind-powered desalination plant to be completed in two phases: phase one in 2006 would involve the installation of 8.5MW of wind energy, to then be increased to 13.5MW by 2010 in phase two.

The use of solar desalination has also been piloted. An experiment was conducted in the region of Marrakech that estimated the cost of solar desalination at €0.25 per m^3 (2006). The study used MSF technology to desalinate water at a rate of $1500m^3$/day. Another study estimated the cost of desalinating seawater powered by wind turbines. They established that grid-connected wind turbines using RO technology was the most feasible and cost effective solution[261].

Morocco is now investing in renewable technologies and producing the most favourable renewable energy policies in the MENA region. Renewable desalination is expected to soon provide a viable solution to the nation's water scarcity issues. Increased renewable energy development will assist the nation's economy by reducing energy imports and by creating employment in a new domestic industry.

261 Rizzuti, L, Ettouney, H.M, Cipollina, A. (2007) Solar desalination for the 21st Century: A review of modern technologies, Springer pub, Netherlands.

GLOSSARY:

AEMO	Australian Energy Market Operator *(Oceania)*
AER	Australian Energy Regulator *(Oceania)*
AFD	Agence Fracaise Development *(French Development Agency) (MENA)*
AMCOW	African Ministers Council on Water *(South Africa)*
CCGT	Combined Cycle Gas Turbine
CDER	Centre for Renewable Energy Development *(MENA)*
COAG	Council of Australian Governments *(Oceania)*
COP	Cherifien Office of Phosphates *(MENA)*
CROP	Council of Regional Organisations in the Pacific *(Oceania)*
CSP	Concentrated Solar Power
DME	Department for Minerals and Energy *(South Africa)*
DWAF	Department for Water Affairs and Forestry *(South Africa)*
GCC	Cooperation Council for the Arab States of the Gulf *(MENA)*
GFH	Gulf Finance House *(MENA)*
GHG	Green House Gas
IDA	International Desalination Association
IDA	International Development Agency
IMO	Independent Market Operator *(Oceania)*
IPP	Independent Power Producer
IRDP	Integrated Rural Development Programme *(South Africa)*
IRENA	Institute for Renewable Energy Agency *(MENA)*
IREP	Institute for Renewable Energy Policy *(MENA)*
ISCC	Integrated Solar Combined Cycle
IUCN	International Union for Conservation of Nature *(Oceania)*
IWRM	Integrated Water Resource Management *(Oceania)*
kW	Kilowatt: 1,000 watts
kWh	Kilowatt-hour
MDG	Millennium Development Goals

MEB	Multiple Effect Boiling
MEE	Multi Effect Solar Evaporation
MEMEE	Ministère de l'Energie, des Mines, de l'Eau et de l'Environnement (Ministry of Energy, Mining, Water and Environment) *(MENA)*
MENA	Middle East and North Africa
MSF	Multi-stage Flash
Mtoe	Million Tonnes of Oil Equivalent
MW	Megawatt: 1,000,000 watts
NEM	National Electricity Market *(Oceania)*
NERSA	National Energy Regulators South Africa *(South Africa)*
NMBM	Nelson Mandela Bay Municipality *(South Africa)*
NPAP	National Plan of Action Priority *(MENA)*
NWC	National Water Commission *(Oceania)*
ONEE	Office National d'Electricite et d'Eau (National Office of Electricity and Water) (MENA)
ONEP	Office National de l'Eau Potable (National Office of Potable Water) (MENA)
OPEC	Organisation of the Petroleum Exporting Countries
PAGER	National Water & Sanitation Programme *(MENA)*
PCCR	Pacific Climate Change Round Table *(Oceania)*
PCEG	Pacific Centre for Environmental Governance *(Oceania)*
PERG	Rural Electrification Programme Global *(MENA)*
PIDP	Pacific Islands Development Programme *(Oceania)*
PIEPP	Pacific Islands Energy Policy and Plan *(Oceania)*
PV	Photovoltaic
RDP	Reconstruction and Development Programme *(South Africa)*
RED	Regional Electricity Distributer
REFIT	Renewable Energy Feed-In-Tariff
REFSO	Renewable Energy Finance and Subsidy Office *(South Africa)*
REGA	Renewable Energy Generators of Australia *(Oceania)*
RGA	Renewable Generators Association *(Oceania)*

RO	Reverse Osmosis
SADC	South African Development Community *(South Africa)*
SALGA	South African Local Government Association *(South Africa)*
SANERI	South Africa National Energy Research Institute *(South Africa)*
SAPP	South African Power Pool *(South Africa)*
SCIP	Seven Countries Interconnection Project *(MENA)*
SEC	Saudi Electric Corporation *(MENA)*
SPREP	South Pacific Regional Environmental Programme *(Oceania)*
SWH	Solar Water Heaters
SWIS	Southwest Interconnected System *(Oceania)*
TEC	Tuvalu Electric Corporation *(Oceania)*
TREC	Trans Mediterranean Renewable Energy Corporation *(MENA)*
UNDP	United Nations Development Programme
UNESCO	United Nations Educational Scientific and Cultural Organisation
URP	Urban Renewal Programme *(South Africa)*
VANREPA	Vanuatu Renewable Energy Power Association *(Oceania)*
WEM	Wholesale Electricity Market
WMO	World Metrological Organisation
WRC	Water Research Commission *(South Africa)*
WSAA	Water Services Association of Australia *(Oceania)*