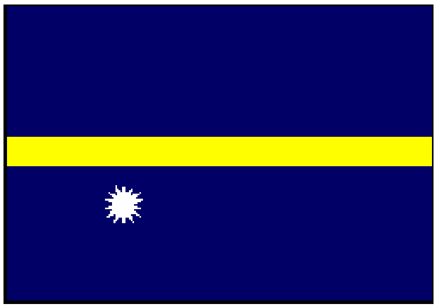
Moving Towards Energy Security: Renewable Energy and Energy Conservation Strategies and Policy Recommendations for the Republic of Nauru



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&

The Government of the Republic of Nauru

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Table of Contents

	List of Acronyms	**4**
1.	**Executive Summary**	**5**
2.	**Introduction**	**6**
	2.1. The Use of Nauru as a Model for SIDS	**6**
	2.2. Background and Context for Action	**7**
	2.3. Current Energy Production	**7**
	2.4. Fossil Fuel Market Volatility	**7**
3.	**Energy Conservation & Efficiency**	**10**
	3.1. Energy Conservation through Demand Side Management	**10**
	3.2. Energy Conservation through Efficient Appliance Technologies	**12**
	3.2a Refrigeration	**12**
	3.2b Clothes Washers	**15**
	3.2c Electric Stoves	**17**
	3.2d Air Conditioners	**18**
	3.2e Lighting	**20**
	3.2f Other Appliances	**23**
	3.3. Strategies for Moving Toward Energy Efficiency	**23**
	3.3a Development and Implementation of Demand Side Management on Nauru	**23**
	3.3b Tax Credits, Subsides or Donor Grants to Offset Initial Capital Costs	**24**
	3.3c Tariff free import licenses for retail	**24**
	3.3d Public Awareness Campaign	**24**
	3.3e Profit Margin set appropriately to provide retail market and labor incentives	**25**
	3.3f Bulk Recycling Contract	**25**
	3.3g Switch Out Program	**26**
	3.3h Phase Out Program	**26**
	3.4. Energy Conservation through Green Building Standards	**28**
4.	**Energy Production Using Renewable Energy Technologies**	**29**

4.1. Solar **30**

4.1a. Solar Panels **30**

4.1b. Passive Solar Water Heaters **33**

4.2. Wind **34**

4.3. Biogas **36**

4.4. Biofuels **38**

5. Policy Options for moving toward Energy Sustainability **41**

5.1. Policy Contexts of Subsidies **41**

5.2. Energy Pricing **41**

5.3. Renewable Energy Subsidies **42**

5.4. Technology Transfers **42**

5.5. Stakeholder Participation **42**

6. Capacity Development and Governance **44**

6.1. Capacity Development as Integral to Sustainability **44**

6.2. Technical and Educational Capacity Building **46**

6.3. Possible Partnerships to Develop Capacity Assessment and Technical Solutions **49**

6.4. Potential Governance Structures for Sustainable Energy Transitions **51**

Appendix 1: Contacts **55**

Appendix 2: Contact Information for University Partnerships **56**

Appendix 3: Physical Geography and Environment **58**

List of Acronyms

ADB	Asian Development Bank
AMU	Aid Management Unit
AOSIS	Alliance of Small Island States
BMP	Best Management Practices
BPOA	Barbados Plan of Action
CDM	Clean Development Mechanism
CSD-15	Commission on Sustainable Development (15^{th} Session)
DPDD	Development Planning and Policy Division
DSM	Demand Side Management
EEZ	Exclusive Economic Zone
EU/EC	European Union/Community
GEF	Global Environment Facility
GHG	Greenhouse Gases
GoN	Government of Nauru
IEA	International Energy Agency
LED	Light Emitting Diode
LEED	Leadership in Energy and Environmental Design
LBNL	Lawrence Berkeley National Laboratories
LUTW	Light up the World Foundation
NGO	Non-Governmental Organization
NIANGO	Nauru Island Association of Non-Governmental Organizations
NIC	National Island Council
NSDS	Nauru National Sustainable Development Strategy
PIC	Pacific Island Countries
SEPCo	Sustainable Energy Policy Concepts
SIDS	Small Island Developing States
USGS	United States Geological Survey
UNDP	United Nations Development Program

1. Executive Summary

Nauru is currently in a position of unsustainable energy production and consumption due to a long history of subsidized energy and a near complete reliance upon fossil fuels. This report explores options to begin to remedy this situation and promote a sustainable energy mix including renewable energy technologies and energy conservation measures.

We discuss demand side energy conservation through the use of modern energy efficient appliances and present a simple quantitative model outlining potential energy and cost savings in multiple scenarios within the domestic sector. We specifically focus on household appliances including: refrigerators, clothes washing machines, electric stoves and air conditioning units. We discuss policy options, market based mechanisms, public awareness and educational campaigns, and conclude that demand side management of new technologies is critical to a sustainable energy policy and could result in significant savings. We also provide pragmatic policy and logistical strategies for replacement and phase out programs, as appropriate per individual appliance category.

Next, we consider renewable energy technologies (including solar panels, passive solar water heaters, wind, biogas and biofuels) and assess the feasibility of implementation for each on Nauru. We conclude that existing projects need to be monitored and new projects begun in order to build capacity and knowledge and that further research is needed in order to determine whether or not such technologies are of immediate economic viability. Using a simple quantitative model, we give potential energy production and direct diesel cost savings in multiple scenarios to demonstrate that significant amounts of energy can be generated using proven renewable energy technologies. We further discuss how utilization of these technologies can help achieve alternate goals such as energy security, reef and beach protection, limit freshwater aquifer contamination from sewage, and mining rehabilitation.

An analysis of the policy context for energy and renewable energy technologies on Nauru (including subsidies, prices and population) concludes that a phase out of energy subsidies that encourage fossil fuel consumption and incentivize energy conservation measures be a priority for the island.

Finally, we discuss the importance of capacity development as an integral part of the transition to a sustainable energy economy and conclude that important initial steps include a capacity assessment across all sectors, the development of appropriate partnerships. We also outline a possible governance structure to help expedite projects aimed at achieving widespread use of renewable energy technologies for electricity production in an effort to achieve energy security.

2. Introduction

Small Island Developing States (SIDS) are very vulnerable to global warming and the impending sea level rise. Lack of energy security combined with but not limited to, high per capita use, lack of widespread renewable energy technologies, remoteness, limited funding, and high fuel prices, make pacific SIDS especially vulnerable to energy security/supply issues.[1] This paper presents strategies that the Government of Nauru (GoN) can implement to face these challenges. Appropriate legislation and development of social programs focused on the utilization of renewable energy technologies, energy conservation measures, capacity building across all sectors. These strategies will help Nauru transition from being entirely reliant on imported diesel fuel to run generators towards a more sustainable energy system that incorporates the use of renewable energy into the existing grid system and strategic conservation measures. Essentially, this paper continues the goal of the National Sustainable Development Strategy (NSDS) by providing a clear and pragmatic plan to enhance the use of renewable energy technologies and to limit demand side energy use.

2.1 The Use of Nauru as a Model for Pacific SIDS

Nauru presents a unique case study that can serve as a model for other Pacific SIDS. The climate is equatorial and is thus similar to other Pacific SIDS. It has both low-lying coastal and uplifted areas. Nauru's relatively small size provides a few advantages as a case study. First, pilot projects would inherently provide a larger relative benefit at a smaller cost, allowing other SIDS see the effectiveness of potential projects, before investing in projects on their islands. This would also provide a framework for other SIDS to scale up in order to meet their needs. Due to the small population, specialists familiar with new technologies may be more difficult to find, so the design and fine tuning of capacity building efforts will have to be a priority in order to ensure effectiveness. The result of this process will be one in which problems common to the region will be addressed leading to better adaptability for other Pacific SIDS. Another factor to consider is that as a result of the mining operation there is a much higher use of electricity per capita, which should allow the effectiveness of energy conservation measures to be more quantifiable. For a more detailed description of physical geography and the environment, social context and political structure, and economics and industries see Appendix I.

[1] United Nations. *Mauritius Strategy.* Port Louis, Mauritius, 10-14 January 2005, A/CONF.207/11

2.2 Background and Context for Action

Nauru currently lacks the administrative structure, regulations, and legislation needed to implement and encourage the widespread use of renewable energy technologies.[2] Chapter VII of the Barbados Programme of Action indicates the importance of incorporating renewable energy sources into current SIDS energy mixes, while simultaneously promoting energy efficiency. Furthermore, it suggests paying special attention to the possibilities of using, where appropriate, economic instruments and incentive structures to increase the economic feasibility of renewable energy.[3]President Scotty Ludwig wrote in the Foreword of the National Sustainable Development Strategy (NSDS) that in order to move ahead in terms of living standards, then Nauruans have to, “accept the fact that government can no longer provide the welfare society...” Furthermore, the goal of achieving fifty percent of energy needs in the infrastructure sector through the development of renewable energy sources was set as a NSDS priority.[4]

2.3 Current Energy Production

This report is operating under the assumptions that (1) the current island-wide grid system is functioning and a maintenance regime is funded, (2) that smart card meter systems are installed and functioning properly for all households, and (3) that the following four diesel powered generators are operational:

Generator	Production Capacity
Ruston	2.0 MW
Paxman	2.0 MW
Paxman	2.0 MW
Caterpillar	1.6 MW
Total Generator Production	**7.6 MW**

2.4 Fossil Fuel Market Volatility

Figure 1 portrays the United States Energy Information Administration’s crude oil price predictions to 2030. Long-term oil prices have been traditionally difficult to predict, nevertheless, the three price paths in Figure 1 are based of different assumptions regarding world oil supply. The reference case uses the United States Geological Survey’s (USGS) worldwide crude oil resource estimate. The high price case assumes that the worldwide crude oil resource is 15 percent smaller than the USGS estimate, and is more costly to produce. The low price case assumes that the worldwide resource is 15

[2] Pacific Regional Energy Assessment 2004. *An Assessment of the Key Energy Issues, Barriers to the Development of Renewable Energy to Mitigate Climate Change, and Capacity Development Needs for Removing the Barriers*. Nauru National Report Volume 7.
[3] Barbados Plan of Action Section 38(A)ii).
[4] Nauru, *National Sustainable Development Strategy 2005-2025*. (NSDS).

percent more plentiful than the USGS estimate, and is less expensive to produce.[5] Therefore, the major price differences across the three cases reflect uncertainty with regard to both the supply of resources and production costs.

Oil prices have been highly volatile over the past 25 years principally due to unforeseen political and economic circumstances, and oil resources are not expected to be a key constraint on world crude prices to 2030. Rather, it is expected that political, economic, and environmental factors will be the key drivers of oil supply and demand.[6] For example, it is widely recognized that tensions in the Middle East could give rise to serious disruptions of normal oil production and trading patterns, and the growing concern over the effects of global warming may also lead to unforeseen price volatility.

This volatility in supply and pricing are further compounded by a number of factors unique to SIDS. Since most small islands are heavily dependent upon imported fossil fuels to generate electricity, dramatic fluctuations in oil prices can have measurable impacts on these small economies.[7] SIDS with narrow production bases import more frequently than they are able to export. This results in outbound transport not being used to full capacity and hence they attract even higher transport costs.[8] The ratio of petroleum imports to total exports for Pacific SIDS ranges from approximately 10% for Papua New Guinea to over 400% for Marshall Islands, Palau and Tuvalu.[9] Furthermore, due to the inherent small demand, remoteness, and lack of larger port facilities, island nations may rely on smaller, less seaworthy coastal supply vessels that visit less frequently[10]. The result of these obstacles to supply is prices that are often 200-300% above world market rates and may represent up to 50% of public spending[11]. With ever increasing demand for fossil fuels and projected diminishing supplies, SIDS may not posses the resources and political sway necessary to compete with more powerful parties and ensure an adequate and consistent supply.

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[5] EIA 2006. *International Energy Outlook.* Accessed 4.29.07. Available at http://www.eia.doe.gov/oiaf/ieo/oil.html

[6] EIA 2006. *International Energy Outlook.* Accessed 4.29.07. Available at http://www.eia.doe.gov/oiaf/ieo/oil.html

[7] Stuart, EK. *Energizing the island community: a review of policy standpoints for energy in Small Island States and Territories.* Sustainable Development 2006 14:139-147

[8] Fischer, G & Encontre, P. *The economic disadvantages of Island Developing Countries: problems of smallness remoteness & economies of scale.* Island Living Series 1992 2:69-88

[9] Jafar, M. *Renewable energy in the South Pacific – options and constraints.* Renewable Energy 2000 19:305-309

[10] Yu, X & Taplin, R. *Policy perspectives: environmental management and renewable energy in the Pacific Islands.* Journal of Environmental Management 1997 51:107-122

[11] Weisser, D. *On the economics of electricity consumption in small island developing states: a role for renewable energy technologies?* Energy Policy 2004 32:127-140

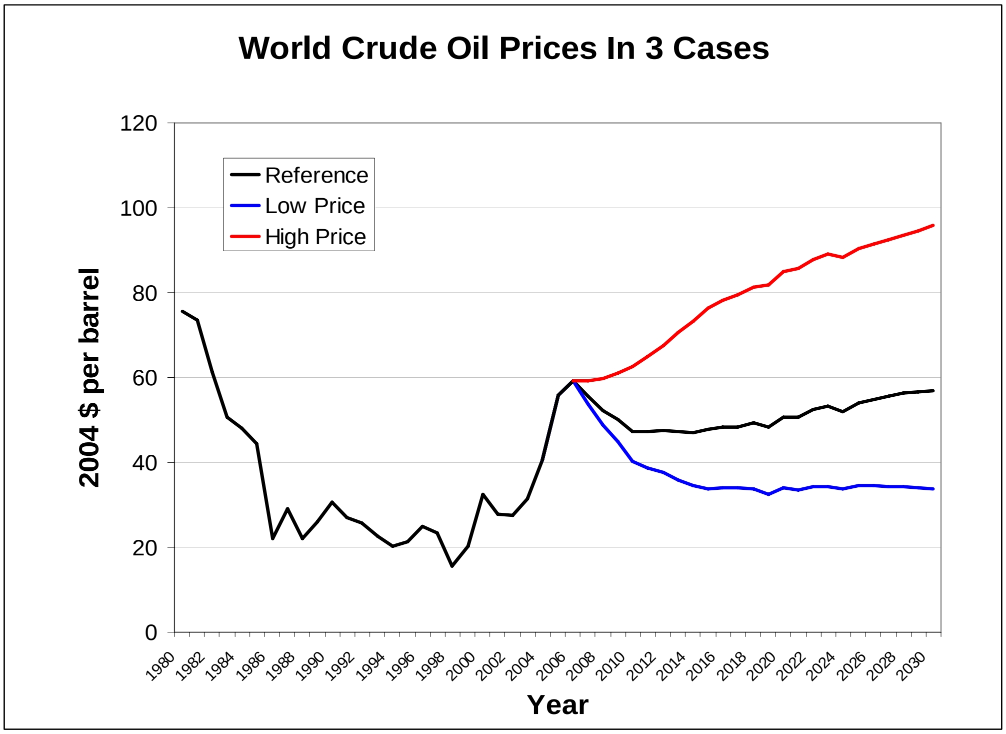


Figure 1.[12] 50 Year Projection of World Crude Oil Prices.

Given these external pressures and uncertainty, Nauru's dependency on diesel generators could exacerbate the country's economic vulnerability in the future and further expose Nauru's economic livelihood to exogenous factors. Thus, movement away from fossil fuel dependency would insulate the economy from factors outside of the country's control, and would lead to increased economic stability and national sovereignty. At the Intergovernmental Preparatory Meeting for the CSD-15, AOSIS uniformly requested technology transfer, capacity building, and financial assistance in order to implement renewable technologies. It is the position of this paper that Nauru would serve as an excellent proving ground for such projects, and fully supports initiatives to be formulated at the CSD-15.

[12] Energy information administration: 2006 International Energy Outlook. Prices in US $. Available From http://www.eia.doe.gov/oiaf/ieo/index.html

3. Energy Conservation and Efficiency

Recommendations:

1. Implement demand side management to increase energy efficiency.
2. Develop capacity and partnerships for a refrigerator switch out program to present to potential donors.
3. Develop phase out programs of less efficient technologies through import standards. Washing machines and air conditioners should be made a priority but other appliances should be considered as well.
4. Explore replacement options for electric stoves.
5. A mandatory technology exchange for light bulbs should be instituted for all remaining incandescent bulbs utilizing LED and CFL lighting in both the public and private sectors dependent on the lighting needs.
6. Create Policies requiring that new government buildings, residential housing, and retrofits to existing structures adhere to LEED standards.

Nauru has opportunity to improve the efficiency as a first step towards a sustainable energy policy. This section discusses a two fold strategy to increased energy efficiency which includes alterations to energy management and to current technologies. The first step to improved energy efficiency is creating a management system which attempts to encourage limited energy use. Starting in 2003, pilot projects using these management paradigms were implemented in selected Pacific Island Nations.[13] The second step towards improving energy efficiency is to begin switching to available "off the shelf" energy efficient technologies which could drastically cut down on Nauru's energy demand. Many countries have pursued these tactics to both reduce national energy use and to increase awareness of energy issues among consumers.[14] In addition, it is important to remember that energy saved by efficiency measures immediately frees up capital which can be put towards other sustainability projects and goals.[15]
An increase in demand side energy efficiency is imperative for moving Nauru towards more sustainable energy practices.

3.1 Energy Conservation through Demand Side Management

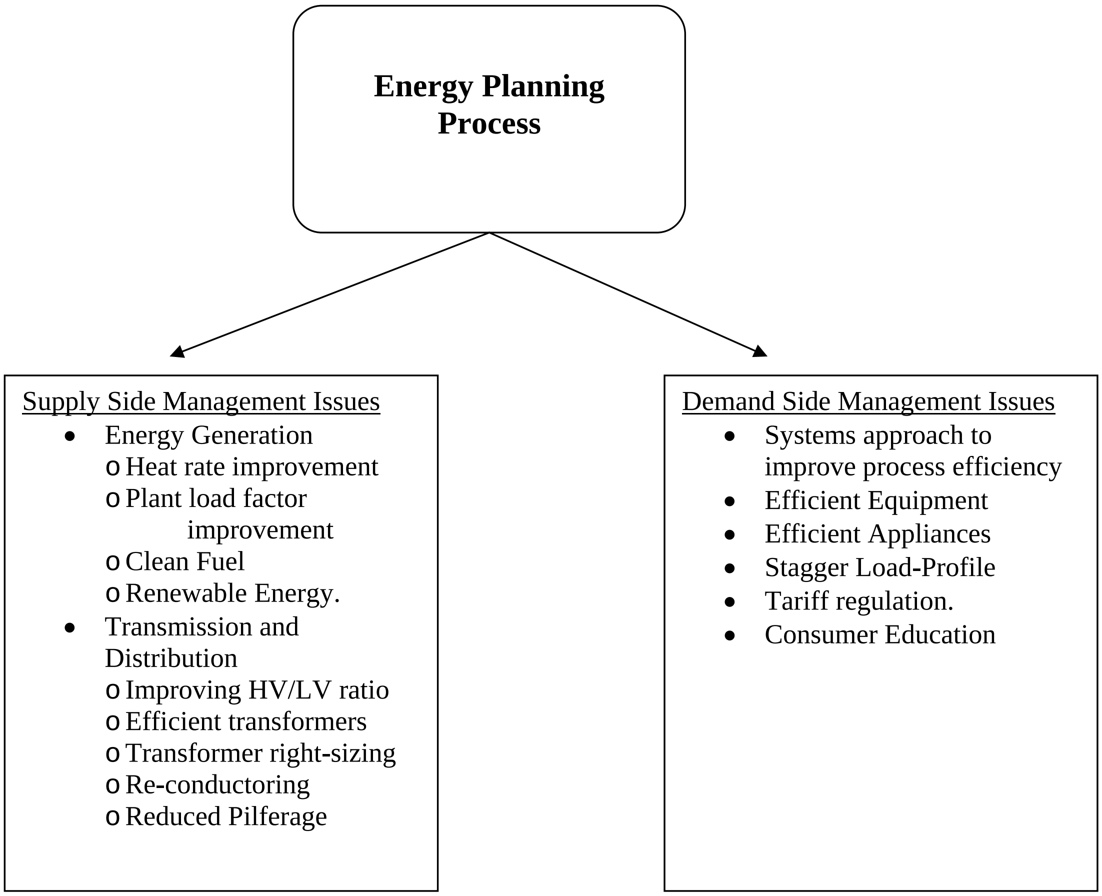
Half of the equation necessary to move Nauru towards a sustainable energy program is to analyze and improve Nauru's demand side efficiency. Demand Side Management (DSM) refers to cooperative activities between the energy utility and its customers which results

[13] International Institute for Energy Conservation. *Demand Side Management Best Practices Guidebook for Pacific Island Power Utilities.* July 2006. Page 8. Available at www.sidsnet.org/docshare/other/20070110DSMBestpractices.pdf

[14] ESI Africa. *Appliance Energy Efficiency Labeling.* Accessed 2.21.07. Available at www.esi-africa.com/archive/esi_1_2004/40_1.php. Accessed 2/21/07

[15] Environmental Energy Technologies Division (EETD) at Berkeley Lab. "*CLASP's International Success.*" Accessed 3/13/07. Available at http://eetdnews.ibl.gov/nl15/clasp.html.

in increased energy efficiency.[16] It should be considered equally important as finding alternative energy sources for Nauru to reach a situation of energy sustainability.[17] DSM should be a dynamic process, in which planning, implementation and evaluation form a feedback loop which ensures adaptive management processes. Demand side planning should include technical options and behavioral options for energy consumers.[18]



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[16] International Institute for Energy Conservation. "*Demand Side Management Best Practices Guidebook for Pacific Island Power Utilities.*" July 2006. Page 9. Available at www.sidsnet.org/docshare/other/20070110DSMBestpractices.pdf

[17] Ornl.gov. *Power to the People: Electricity Planning in Developing Countries.* Accessed 3/14/07. Available at http://www.ornl.gov/info/ornlreview/rev28_2/text/irp.htm

[18] Ibid

DSM activities were first introduced in the Pacific Island region in 1993 – 1996 through the UNDP funded "Support to the Pacific Islands Power Sector Project." DSM assessments were conducted on 10 Pacific Island Country utilities. Through this, "nine cost effective DSM programmes were identified with a total peak demand savings potential of 21 MW across the ten utilities with an equivalent energy savings of 90GWh/year by 2000."[19] While Nauru was not a part of this assessment, it seems likely that Nauru could also benefit from DSM activities.

Currently Nauruans are not paying the true cost of their energy. Unless residents are paying for their energy, there is no financial incentive to switch to more efficient modes of energy use therefore it is unlikely that Nauru will build much enthusiasm behind increasing demand side efficiency.

3.2 Energy Conservation through Efficient Appliance Technologies

Because of the free energy provided to the island of Nauru until the 1990s from the phosphate mining operation, the population of Nauru has never had a financial incentive to reduce energy use. As such, many appliances are currently used extensively on the island, including air conditioners, refrigerators, and washing machines. Based on research conducted by Sustainable Energy Policy Concepts (SEPCo), "the most important energy consumers in low-income homes are refrigerators, lights and stoves (or fireplaces)."[20] Nauru's appliance use exceeds that of other developing countries with current domestic energy bills averaging between A$200-$300 per month.[21] Ensuring that appliances are efficient in their use of energy is imperative to reducing demand side energy use.

3.2a Refrigeration

Currently in Nauru, 73% of households have one or more refrigerators (see figure 2).[22] If demand side energy efficiency is to be achieved on Nauru, there needs to be an effort to improve the energy efficiency of residential refrigeration units.

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[19] International Institute for Energy Conservation. *Demand Side Management Best Practices Guidebook for Pacific Island Power Utilities.* July 2006. Page 7. Available at www.sidsnet.org/docshare/other/20070110DSMBestpractices.pdf

[20] Sustainable Energy Policy Concepts. *Energy Efficiency in Households.* Accessed 2.21.2007. Available at www.ises.org/sepconew/Pages/Menu/menuefficiency.html

[21] European Community. *Nauru: Country Strategy Paper and National Indicative Programme for the period 2002-2007*. Page 12.

[22] Asian Development Bank. *Reform of Nauru, Draft Final Report.* Page 250.

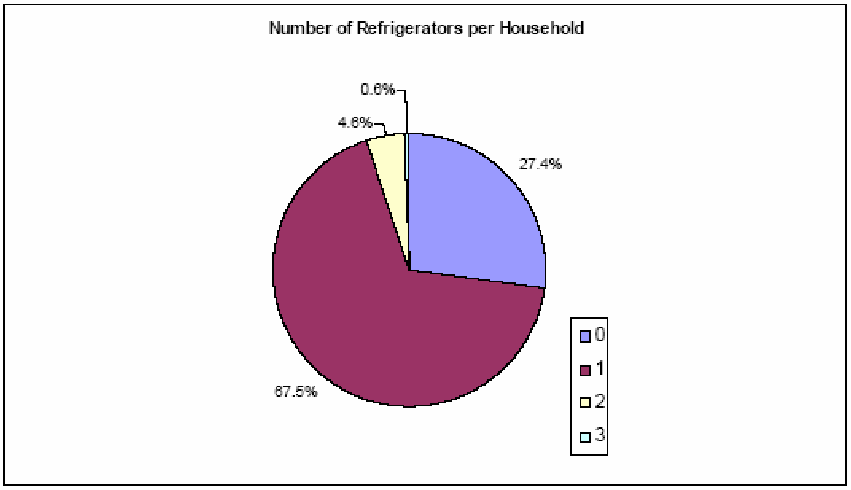

Figure 2[23] Refrigerators per Household in Nauru

From studies conducted in Cuba, it seems refrigerators are often the largest consumers of power. In this study, it was shown that the average consumption of energy by refrigerators was 900kWh per year.[24] If that holds true in Nauru, than roughly 12% of household energy use is due to refrigerators. Additionally, in China, it was found that in urban households, refrigerators account for at least half of all residential energy consumption.[25] China saw a 40% increase in energy efficiency use by refrigerators by switching to more sustainable models.[26] This section argues that replacing the current refrigerating units with more efficient appliances will translate into significant energy and cost savings.

Energy and Cost Quantification

The following section quantifies the amount of energy that could be saved by replacing old refrigeration/freezer units and the subsequent cost and energy savings. It uses three scenarios; where (#1) current units are assumed to be manufactured between 1980 and 1990, (#2) 1990 and 1992, and (#3) 1992 and 2000. Furthermore it looks at two different models; type A and type B (see figure 3). All calculations are based on replacing all of the current units used in the domestic sector with new Energy Star™ certified units. It is important to note that while Energy Star™ is the US certification scheme, other similar certification schemes exist in other countries.

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[23] Ibid
[24] Ises.org. "*SEPCo: Energy Efficiency in Households.*" Accessed 2/21/07. Available at www.ises.org/sepconew/Pages/Menu/menuefficiency.html.
[25] UN.org. "Case Study of the China Energy Efficient Refrigerator Project." Accessed 3.15.07. www.un.org/esa/susdev/csd/casestudies/e3_c3_China.pdf.
[26] Ibid page 7

Type A: Side-by-side refrigerator freezer	Type B: Top loading refrigerator freezer
	

Figure 3: Two model types of refrigerators.

<table>
<tr><th><u>Refrigeration</u></th><th><u>Details</u></th></tr>
<tr><td>Qualifying Metrics and Assumptions</td><td>

1209 refrigerators in 1154 Households (Calculated from 2005 census and ADB Report)
Energy Cost: Aus $ 0.358 / KWh (ADB estimate)
Two model types (A & B see Figure 4) with volumes of 21.5 – 24.5 cubic feet.
Manufacture date: 3 scenarios: 1980 – 1989, 1990 – 1992, 1993 – 2000

</td></tr>
<tr><td>Energy Savings and Cost Savings</td><td>
Scenario #1 Current Refrigerators Manufacture Date 1980 - 1989

<u>Per Household</u>
<table>
<tr><th>Model Type</th><th>Energy Savings</th><th>Cost Savings</th></tr>
<tr><td>Type A</td><td>~ 2,466 KWh / yr. per appliance</td><td>~ Aus $ 715 / yr per appliance</td></tr>
<tr><td>Type B</td><td>~ 1,970 KWh / yr. per appliance</td><td>~ Aus $ 570 / yr per appliance</td></tr>
</table>
<u>For Entire Domestic Sector</u>
<table>
<tr><th>Model Type</th><th>Energy Savings</th><th>Cost Savings</th></tr>
<tr><td>Type A</td><td>~ 2,981,000 KWh / yr.</td><td>~ Aus $ 865,000 / yr</td></tr>
<tr><td>Type B</td><td>~ 2,382,000 KWh / yr.</td><td>~ Aus $ 690,000/ yr</td></tr>
</table>
Scenario #2 Current Refrigerators Manufacture Date 1990 – 1992

<u>Per Household</u>
<table>
<tr><th>Model Type</th><th>Energy Savings</th><th>Cost Savings</th></tr>
<tr><td>Type A</td><td>~ 1,245 KWh / yr. per appliance</td><td>~ Aus $ 361 / yr per appliance</td></tr>
<tr><td>Type B</td><td>~ 993 KWh / yr. per appliance</td><td>~ Aus $ 288 / yr per appliance</td></tr>
</table>
</td></tr>
</table>

For Entire Domestic Sector

Model Type	Energy Savings	Cost Savings
Type A	~ 1,505,000 KWh / yr.	~ Aus $ 436,000 / yr
Type B	~ 1,200,500 KWh / yr.	~ Aus $ 348,000 / yr

Scenario #3 Current Refrigerators Manufacture Date 1993 – 2000

Per Household

Model Type	Energy Savings	Cost Savings
Type A	~ 583 KWh / yr. per appliance	~ Aus $ 169 / yr per appliance
Type B	~ 483 KWh / yr. per appliance	~ Aus $ 140 / yr per appliance

For Entire Domestic Sector

Model Type	Energy Savings	Cost Savings
Type A	~ 705,000 KWh / yr.	~ Aus $ 204,000 / yr
Type B	~ 584,000 KWh / yr.	~ Aus $ 170,000 / yr

Barriers to Implementation	Recommended Strategy (Discussed in Section 3.3)
(a) Initial Capital Costs	3.3b Tax credits, subsidies, or donor grants to offset initial capital cost
(b) Import tariffs	3.3c Tariff free import license for retail importers
(c) Public willingness to switch technologies	3.3d Public awareness campaign
(d) Retailers and installation staff	3.3e Profit Margin set appropriately to provide retail market and labor incentives
(e) Disposal of old technology	3.3f Bulk recycling contract 3.3g Switch-out program

Energy and Cost Savings

The calculations validate the clear need for Nauru to phase out old refrigeration units in the domestic sector. Although the direct costs savings fluctuate depending on the type of units that are predominate and the manufacture date range of current units, there are still significant possible savings regardless of the current situation. Assuming there is a mix of both model types and that units were most likely purchased during the mid 1990's during the mining boom, we would expect significant savings to be achieved with a phase out of the current units.

3.2b *Clothes Washing Machines*

Currently, 55% of households own clothes washing machines.[27] Washing machines consume large amounts of water and electricity every time they are run. More efficient washing machines can wash and clean clothes using 50% less energy and cut water use approximately in half, preserving precious water supplies.[28]

[27] Asian Development Bank. *Reform of NPC, Draft Final Report.* Page 246-251.
[28] Energy Star. *Appliances: Clothes Washers.* Accessed 4.14.07. Available at http://www.energystar.gov/index.cfm?c=clotheswash.pr_clothes_washers.

Clothes Washers	Details
Qualifying Metrics and Assumptions	• 922 washing machines (Calculated from 2005 census and ADB Report) • Energy Cost: Aus $ 0.358 / KWh (ADB estimate) • Water Cost: Aus $3.00 / gallon (ADB estimate) • 21% who have electric water heaters have clothes washers (assumption) • Remaining 34% use gas to heat water or do not heat water for clothes washing (assumption) • Based on data for new conventional clothes washers • Assumes 8 loads of laundry a week
Energy Savings and Cost Savings	(see tables below)

Per Household

Type of water heater	Energy Savings	Water Cost Savings	Total Cost Savings (water and energy)
Electric	~ 234 KWh / yr.	~ Aus $17 / yr	~ Aus $ 123 / yr
Gas or none	~ 30 KWh / yr.	~ Aus $17 / yr	~ Aus $ 28 / yr

For Entire Domestic Sector

Type of water heater	Energy Savings	Water Cost Savings	Total Cost Savings (water and energy)
Electric	~ 104,544 KWh / yr.	~ Aus $ 5,922 / yr	~ Aus $ 43,349 / yr
Gas or none	~ 16,929 KWh / yr.	~ Aus $ 9,590 / yr	~ Aus $ 15,650 / yr
Total	~ 121,473 KWh / yr	~ Aus $ 15,582	~ Aus $ 58,999 / yr

Barriers to Implementation	Recommended Strategy (Discussed in Section 3.3)
(a) Initial Capital Costs	3.3b Tax credits, subsidies, or donor grants to offset initial capital cost
(b) Import tariffs	3.3c Tariff free import license for retail importers
(c) Public willingness to switch technologies	3.3d Public awareness campaign
(d) Retailers and installation staff	3.3e Profit Margin set appropriately to provide retail market and labor incentives
(e) Disposal of old technology	3.3f Bulk recycling contract 3.3h Phase-out program

Energy and Cost Quantification

The following section quantifies the amount of energy that could be saved by phasing out conventional clothes washers for more energy efficient models. Calculations were conducted assuming that 21% of households with had electric water heaters also had clothes washers. The remaining 34% of households with washing machines were assumed to use gas to heat water or did not heat water for clothes washing. Water cost savings in addition to energy savings are calculated and a total cost savings is presented. All calculations are based on replacing all of the current units used in the domestic sector with new Energy Star ™ certified units and keeping type of water heating the same.

Energy and Cost Savings

The calculations validate the yearly energy savings Nauru could gain with a phase out of non-energy efficient washing machines. Although the direct costs savings fluctuate depending on the type of units that are predominate and the manufacture date range of current units, there are still significant possible savings regardless of the current situation.

3.2c Electric Stoves

Currently, 63% of households own an electric stove.[29] While data on the energy efficiency of electric stoves is not as available as for other appliances, one estimate states that an average family of 4 uses about 500 kilowatt-hours per year to cook with an electric range/oven combination.[30] Average household size in Nauru is 6 persons (2002 Census). Prorating KWh per person, that would mean an average household would use approximately 750KWh annually to cook with an electric range/oven combination.

Energy and Cost Quantification

The following section quantifies the amount of energy used by electric stoves per year. While no data on replacement of electric stoves is listed, given that the cost of electricity used by electric stoves ranks with that used by refrigerators, reducing energy use from electric stoves is a large area of opportunity for better demand side management. More research will need to be conducted to determine what other options exist for cooking on the island.

<table>
<tr><th>Electric Stoves</th><th colspan="2">Details</th></tr>
<tr><td>Qualifying Metrics and Assumptions</td><td colspan="2">1057 electric stoves (based on 2005 census numbers and ADB Report)
Energy Cost: Aus $ 0.358 / KWh (ADB estimate)
6 people per household (based on 2002 census)</td></tr>
<tr><td>Energy Savings and Cost Savings</td><td colspan="2">Per Household
<table><tr><th></th><th>Energy Used</th><th>Total Cost</th></tr><tr><td>Electric Stove</td><td>~ 750 KWh / yr.</td><td>~ Aus $ 268 / yr</td></tr></table>For Entire Domestic Sector
<table><tr><th></th><th>Energy Used</th><th>Total Cost</th></tr><tr><td>Electric Stove</td><td>~ 792,382 KWh / yr.</td><td>~ Aus $ 283,673 / yr</td></tr></table></td></tr>
<tr><td colspan="2">Barriers to Implementation

(a) Suitable Replacement Unknown
(b) Public willingness to switch technologies</td><td>Recommended Strategy (Discussed in Section 3.3)

3.3i Replacement Technology Task Force
3.3h Phase-out program</td></tr>
</table>

[29] Asian Development Bank. *Reform of NPC, Draft Final Report.* Page 246-251
[30] Efficiency Vermont. *Residential: Appliances.* Accessed 4.14.07 Available at http://www.efficiencyvermont.com/pages/Common/askrachael/Appliances/#A14

3.2d Air Conditioning

Currently, almost 50% of households in Nauru own air conditioners.[31] While air conditioning systems provide the most comfortable in-home temperatures, due to their high energy use, it is necessary to promote consumer awareness strategies for air conditioning use and a phase-out of inefficient units. Room air conditioners provide a useful and valid solution for saving energy.

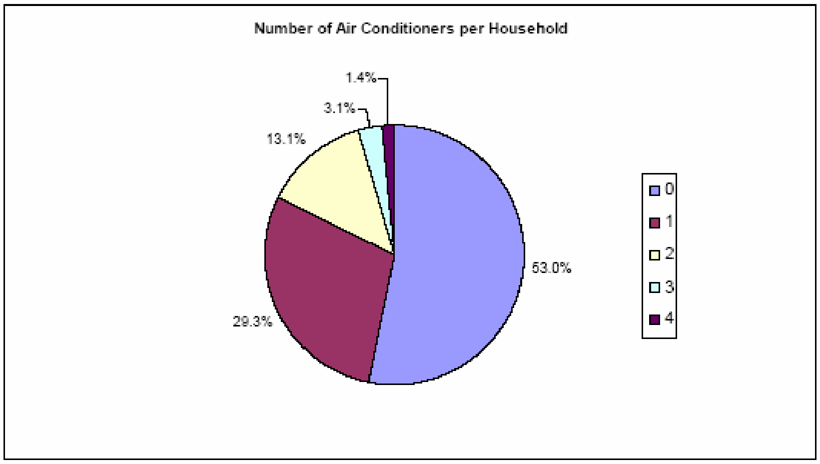

Figure 4[32]: Air Conditioners per Household in Nauru

Room air conditioners (aka: window air conditioners) cool specific rooms rather than the entire homes or businesses.[33] While the replacement of air conditioning units with ceiling fans or other lower-energy cooling systems would cause the greatest reduction in energy, air conditioners provide the most comfortable in-home temperatures.

Energy and Cost Quantification

The following section quantifies the amount of energy that could be saved by the phasing out of old air conditioning units and the subsequent cost and energy savings. It uses three scenarios based on the full load cooling hours that the air conditioner would be expected to provide. Data for full load cooling hours is from Honolulu, HI, Tampa, FL, and the U.S. Department of Energy's average estimate for climate region 12.[34] All calculations are based on replacing all of the current units used in the domestic sector with new Energy Star certified units.

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[31] Asian Development Bank. *Reform of NPC: Draft Final Report.* Page 91.
[32] IBID, Page 250
[33] US Department of Energy. *A Consumer's Guide to Energy Efficiency and Renewable Energy: Room Air Conditioners.* Accessed on 03.04.07. Available at http://www.eere.energy.gov/consumer/your_home/space_heating_cooling/index.cfm/mytopic=12420
[34] Energy Star. *Appliances: Room Air Conditioners.* Accessed 4.14.07. Available at http://www.energystar.gov/index.cfm?c=roomac.pr_room_ac

Air Conditioning	Details
Qualifying Metrics and Assumptions	• 833 air conditioners (calculated from 2005 census numbers and ABD Report) • Energy Cost: Aus $ 0.358 / KWh (ADB estimate) • Two scenarios: Full load cooling hours 5016 (based on data from Honolulu, HI) and full load cooling hours at 3068 (based on data from Tampa, FL) and 2500 (average full load cooling hours from climate region 12). • Based on data for conventional air conditions after 1994 • Cooling capacity of air conditioner: 10,000 Btu/hr
Energy Savings and Cost Savings	See tables below

Energy Savings and Cost Savings

Per Household

Full load cooling hours	Energy Savings	Cost Savings
5016	~ 438 KWh / yr.	~ Aus $ 173 / yr
3068	~ 296 KWh / yr.	~ Aus $ 106 / yr
2500	~ 241KWh / yr.	~ Aus $81 / yr

For Entire Domestic Sector

Full load cooling hours	Energy Savings	Cost Savings
5016	~ 402, 575 KWh / yr.	~ Aus $ 144, 122 / yr
3068	~ 246, 232 KWh / yr.	~ Aus $ 88, 151/ yr
2500	~200, 646 KWh/yr	~ Aus $ 71, 831/yr

Barriers to Implementation	Recommended Strategy (Discussed in Section 3.3)
(a) Initial Capital Costs	3.3b Tax credits, subsidies, or donor grants to offset initial capital cost
(b) Import tariffs	3.3c Tariff free import license for retail importers
(c) Public willingness to switch technologies	3.3d Public awareness campaign
(d) Retailers and installation staff	3.3e Profit Margin set appropriately to provide retail market and labor incentives
(e) Disposal of old technology	3.3f Bulk recycling contract 3.3h Phase Out

Energy and Cost Savings

The calculations validate the yearly energy savings Nauru could gain with a phase out of non-energy efficient air conditioners. Although the direct energy and costs savings fluctuate based on the load cooling hours, there are still significant achievable savings.

3.2e Lighting

The immediate replacement or phase out of incandescent light bulbs is likely to be one of the simplest and most cost-effective strategies to pursue. According to the International Energy Agency (IEA)[35], grid-based lighting consumes 19% of total electricity production, which is slightly more electricity than is used by the nations of OECD Europe for all purposes. Incandescent lighting was introduced in the 19th century and is still the predominant vessel for artificial lighting, despite more efficient technologies being introduced. The IEA estimates that without a palpable change in lighting quality, a market shift from inefficient incandescent lamps to Compact Fluorescent Lamps (CFLs) would cut world electricity lighting demand by 18%[1]. Should, there be a switch from incandescent bulbs to LEDs even greater saving would be estimated.

It is likely that Nauru would benefit greatly from the phase-out of the remaining incandescent lighting, as the use of CFLs in other Pacific SIDS has proven extremely beneficial. For example, the introduction of compact fluorescent light bulbs on an island in the Cook Islands reduced electricity demand by 75%[36]. With the introduction of more efficient lighting, it is important to inform users of the long term savings as higher initial costs per bulb are expected. In another CFL program concerning seven countries, participants are expected to avoid almost 3,000 Gigawatt-hours of electricity consumption and the emission of 15 million tons of CO_2 over a ten-year time period[37].

Nauru would also be an excellent setting for the implementation of such a program due to local and global influences. About 25% of energy consumed by CFLs is converted to visible light compared with just 5% for a conventional incandescent lamp. This means that 75% of input energy is output heat in the case of CFLs compared to 95% in the case of incandescent lamps.[38] Furthermore, it has been shown that due to the extensive experience with incandescent lamps, shifting away from this technology seems more difficult in OECD countries than in developing countries where such technological path dependency is more limited[39]. This relative ease could be fomented by recent announcement of new legislation by Australia, which would increase minimum standards on lighting efficiency thereby squeezing incandescent bulbs out of the market[40]. It is likely that this initiative will increase the supply of CFLs to the pacific region and potentially lower costs.

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[35] International Energy Agency. *Light's Labour's Lost – Policies for energy efficient lighting*. 2006. Page 560.
[36] Yu, XJ., Taplin, R. & Akura, T. *A framework for energy policy making in the Pacific Islands.* Energy Policy 1997 25:971-982
[37] IFC Environment. *Efficient Lighting Initiative*. Accessed 2/28/07.
Available at www.ifc.org/ifcext/enviro.nsf
[38] Lefevre, N.; T'Serclaes, P. & Waide P. *Barriers to technology diffusion: The case of compact fluorescent lamps.* .International Energy Agency, 2006. Page 34.
[39] Lefevre, N.; T'Serclaes, P. & Waide P. *Barriers to technology diffusion: The case of compact fluorescent lamps.* International Energy Agency, 2006. Page 34.
[40] Media release by Malcom Turnbull, the Australian Minister for the Environment and Water Resources. Accessed 3/.18/.07. Available at www.environment.gov.au/minister/env/2007/pubs/mr20feb07.pdf.

Replacing one incandescent light bulb with an energy-saving compact fluorescent bulb means 1,000 pounds less carbon dioxide is emitted to the atmosphere and $67 dollars is saved on energy costs over the bulb's lifetime.[41]

The current energy subsidy program on the prevents any real incentive for residents to begin a technology transfer on their own. Since they stand to see financial benefit for technology transfer, it is important for government regulation to play a role in encouraging technology transfer. In South Africa, it was determined that government subsidies for two free light bulbs were "far less expensive and much more sustainable than the subsidy approach."[42]

We suggest that two compact florescent light bulbs be provided per household to residents. Australia would be reasonable partner for trade or donation of these light bulbs, since they encourage the use of CFLs. It is suggested that light bulbs be distributed accompanied by educational material on the benefit of CFL light bulbs.

Solid-State Lighting

Solid state lighting technologies use light emitting diodes (LEDs). LEDs have existed for some time, however only recently the technology has become refined enough to offer practical and diverse applications across the public and private sectors. Using LEDs incurs significant energy and costs savings over all alternate lighting technologies (see figure 5). Solid state lighting can work as both a transition technology and long-term energy efficiency measure and a campaign should be aggressively implemented that helps Nauru transition into the use of LED lighting.

[41] U.S. Environmental Protection Agency and Alliance to Save Energy
[42] SEPCo Document Library. *Energy Efficiency in Households.* Accessed 2.21.07. Available at www.ises.org/sepconew/Pages/Menu/menuefficiency.html.

Lamp Type	Homemade Kerosene	Incandescent	Compact Fluorescent	WLED
Efficiency (Lumens/watt)	0.03	5 - 18	30 - 79	25 - 50
Rated Life (Hours)	Supply of Kerosene	1000	6500 - 15,000	50,000
Durability	Fragile & Dangerous	Very Fragile	Very Fragile	Durable
Power Consumption	0.04 - 0.06 liters/hour	5W	4W	1W
CCT °K	~ 1800°	2652°	4200°	5000°
CRI	~ 80	98	62	82
$ After 50,000 hours	1251	175	75	20

Light Comparison Table

Figure 5. Table demonstrates the significant energy savings when white light LEDs (WLED). [43]

LED Domestic

Numerous projects have been successfully implemented that light homes. For example, the Philippine Environment Lighting Project, which was completed in 2004, utilized an extensive training program to train local citizens in installation and use of micro credit facilities for photovoltaic systems to power LED systems in 30 homes. Furthermore, the Philippines National Oil Company Lighting Project is currently expanding the idea to bring long-term LED lighting solutions to more than 1000 homes. It should also be encouraged that LED lights can be used as replacement bulbs to conserve energy and costs (see figure 6).

Figure 6. LED lighting bulbs and fixtures.

[43] Light up the World Foundation. Accessed 03-.05-.07. Available at http://www.lutw.org

LED Public

LED lighting should be extensively used in the public sector. Uses include but are not limited to the following: traffic signals, airport runway lighting, interior lighting, traffic sign lighting, and street lighting.[44] Companies are producing LED that come in weather-resistant casings with electrostatic discharge protection to ensure durability and prolonged outside use. Samples of the HLMP-CWx8 and HLMP-CWx9 series super bright LED lamps are now available from Agilent and through its worldwide distribution partners. There is a guaranteed four-week delivery lead time for these products.[45] These types of lights would be a good investment by the GoN to ensure high quality long-life government services to the public.

3.2f Other Appliances

There are several other appliances which should also be the target of consumer awareness campaigns and also be replaced with more efficient models, for example: televisions, electric irons, freezers, water pumps, computers, ovens, fans, microwaves and other common kitchen appliances.[46] We would expect the use of more efficient appliances to lead to significant energy use reductions across the domestic and public sector.

3.3 Strategies for moving towards Energy Efficiency

In sections 3.1 and 3.2 we discuss a number of mechanisms which can promote increased energy efficiency. In this section, we discuss our recommendations for strategies to implement these changes. Below is a quick reference chart which matches specific mechanisms to the strategy that best fits them.

	3.3a	3.3b	3.3c	3.3d	3.3e	3.3f	3.3g	3.3h	3.3i
3.1 Demand Side Management	Yes	-----	-----	-----	-----	-----	-----	-----	----
3.2a Refrigerators	-----	Yes	Yes	Yes	Yes	Yes	Yes	-----	----
3.2b Clothes Washers	-----	Yes	Yes	Yes	Yes	Yes	-----	Yes	----
3.2c Electric Stove	-----	-----	-----	-----	-----	-----	-----	Yes	Yes
3.2d Air Conditioner	-----	Yes	Yes	Yes	Yes	Yes	-----	Yes	----

3.3a Develop and Implement Implementing Demand Side Management on Nauru

It seems that Nauru may be behind other PICs in developing a DSM program for their island. We strongly recommend that Nauru begin developing a DSM program to help

[44] Energy Star. Accessed 02.11.07. Available at http://www.energystar.gov/index.cfm?c=traffic.pr_traffic_signals
[45] Compoundsemi.com. *Agilent Technologies Introduces Industry's First Super Bright White LEDs with Electrostatic Discharge Protection.* Accessed0 3.10.07. Available at http://compoundsemi.com/documents/view/cldoc.php3?id=3844#top
[46] Asian Development Bank. *Reform of NPC, Draft Final Report.* Page 246-251.

improve energy efficiency on the island. Efficiency measures can help free up capital which would otherwise be spent on energy. That capital can then be put towards other sustainability projects and goals, such as developing alternative energy on the island.[47]

There already exists fantastic literature on how to develop and implement Demand Side Management in Pacific Island Countries. We recommend that Nauru obtain the "Demand side Management Best Practices Guidebook" (available at www.sidsnet.org/docshare/other/20070110Bestpractices.pdf) to use as a guide for developing their DSM program. This guide book, along with outlining how to develop DSM programs on the island, outlines specific programs which can be presented to potential donors.

3.3b. Tax credits, subsidies, or donor grants to offset initial capital costs.

One key aspect of this transformation will be to institute government regulation which requires the importation of only energy efficient appliances. Overcoming the initial capital costs associated with merchandise, importation, and installation could be funded through either direct government subsidies covering all or part of the merchandise costs, by instituting a tax credit that reimburses consumers for the initial cost, or by donors who support specific programs. It is important to note that for Nauru, substantial costs would be incurred for the purchase and importation of refrigeration units. It is necessary to weigh those costs against long-term costs savings of appliances.

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3.3c Tariff free import licenses for retailer

In order to minimize costs and provide incentives for possible commercial retail partners of a government sponsored program, it is important to create a tariff-free import law for energy efficient technologies.

3.3d Public awareness campaigns

It is important to get public support on the project by exercising transparency with business partners and providing information that makes it clear to them that they will not incur any hidden additional costs. The savings for individuals and society benefit should be stressed.

An example of a public awareness campaign would be one around small changes that can increase the efficiency of air conditioners. This campaign should promote the following:

- Switching off air conditioners when homes or parts of homes are not occupied.[48]
- The use of timers to switch off air conditioners late in the evening when cooling is no longer needed (e.g. at 2am, turning back on at 7am).
- Ensuring that window units are level when installed to make certain the drainage system works properly.[49]

[47] Environmental Energy Technologies Division (EETD) at Berkeley Lab. *CLASP's International Success.* Accessed 3.13.07. Available at http://eetdnews.ibl.gov/nl15/clasp.html.
[48] Ibid

- Placing window units on the shady side of homes or planting trees or shrubs to shade large units. Direct sunlight on the outdoor heat exchange of an air conditioning unit can decrease the air conditioner's efficiency by as much as 10%.[50]
- Avoid placing lamps or televisions near the air conditioner's thermostat. Heat from other appliances can prevent the air conditioner from properly sensing the outside temperature and can cause air conditioners with temperature gages to run longer than necessary.[51]
- Set the thermostat as high as comfortably possible.[52]
- Use interior fans in conjunction with air conditioners to spread cooled air throughout the household.[53]

3.3e Profit Margin set appropriately to provide retail market and labor incentives

Local businesses can be encouraged to participate in the program by setting reasonable profit margins. The importation of Energy Star© or Star rated appliances will most likely be successful if it is implemented via bulk purchasing to take advantage of economies of scale and with specific retailers and installations teams pre-selected to take advantage of the "learning curve" and labor allocation efficiency. If the program is phased-in over a long period of time, there will be significantly higher costs associated with maintained retail floor space and labor contracts. Retailers and installation teams should be trained simultaneously to encourage cooperation and time schedules should be set to ensure a quick and efficient transition to the new technology. Stringent record keeping of new and old units should be a prerequisite. Furthermore, labor rates and profit margins can be pre-set and transparent so that the perceived and actual advantages of participation are clear to citizens.

3.3f Bulk Recycling Contract

If switch out and phase out programs are carried out in an efficient manner, then there will be a large stockpile of outdated appliance. It is important that these units do not become available on the black market of Nauru, or the energy and cost savings that is leveraged to fund the program will be significantly reduced through the continued use. The stockpile may be able to be removed from the island through a recycling contract. The old units will most likely be sold for profit to subsidize the program or can be taken away for free.

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[49] US Department of Energy. *Energy Efficiency and Renewable Energy.* Accessed 3.25.07. Available at http://www.eere.energy.gov/consumer/your_home/space_heating_cooling/index.cfm/mytopic=12420
[50]Ibid
[51] Ibid
[52] Ibid
[53] Ibid

3.3g Switch Out Program

A switch out program is recommended in situations where, through our analysis, we found that it seems the energy and cost savings would be substantial enough to justify a program to replace outdated technology with energy efficient technology. In these situations, it seems that a program specifically targeting replacement of that technology should be developed.

One example of such a program related to refrigerators in Cuba found that private investments in new refrigerators would pay for themselves; private investors would fund refrigeration replacement and then receive credit for avoided costs of generation of electricity over time.[54] Whereas, in the case of China, the Global Environmental Facility (GEF) funded this effort, providing $243,000USD in March 1997 to help with the market transformation to more sustainable refrigeration technology.[55] The goals of the China Refrigerator Project were in part to reduce energy consumption by promotion of improved energy efficiency. A report on the China Refrigeration Project stated, "A key factor in ensuring success of a comprehensive market transformation project is to carefully plan and coordinate activities and to ensure that all stakeholders are involved in both project planning and execution." [56]

3.3h Phase Out Program Using Efficiency Labeling

A phase out program is one in which policies are developed which specifies certain energy standards must be met for all appliances which are imported on the island. One estimate from the UN states that a, "comprehensive use of standards and labels for appliances and other equipment has the potential to reduce electricity consumption and resultant GHG emissions in developing countries by 10-20 percent over the next 20 years."[57]

It is difficult to estimate the exact cost savings over time period of a phase out of old appliances. Much of this estimate depends on the time frame in which older appliances are retired from use and replaced by more energy efficient versions. In addition, it is difficult to take the UN estimates as correct because they assume that some appliance production is occurring in country. However, it is important to set specific energy efficiency standards for appliances that are being imported.

The process for creating this policy should take several steps.

[54] Ibid
[55] Ibid page 2
[56] Ibid
[57] The United Nations: Technical Cooperation. *Energy efficient standards and labeling programme.* Accessed 3/10/07. Available at http://esa.un.org/techcoop/flagship.asp?Code=GLO99095

1) Primary import partners should be researched to determine what their current labeling and regulatory policies are in terms of energy efficient appliances. Prime appliance candidates for energy efficient labeling include:[58]

- Central air conditioning
- Room air conditioning
- Heat pump air conditioning
- Packaged terminal air conditioners and heat pumps
- Packaged air conditioning and heating systems
- Warm air furnaces
- Room heat
- Packaged boilers
- Fans
- Storage water heaters
- Instantaneous water heaters
- Florescent lamp ballasts
- Florescent lamps
- Incandescent reflectors
- HID lamps
- Televisions
- Freezers
- Dishwashers
- Ovens
- Ranges
- Cookpots
- Clothes dryers
- Clothes wasters
- Motors
- Distribution transformers
- Computers

2) Other office equipmentBased on the standards of import partners, energy efficiency standards for appliances must be developed for Nauru. One possible option is to require that certain appliances imported have energy efficiency labeling from the country they are exported.
3) As consumer appliances are retired, it would be necessary to ensure that they are replaced with energy efficient models as designated by Nauru. Therefore, rather than forcing an immediate switch over to more efficient technology, the country can slowly transition as older appliances where out.
4) Methods must be established for proper disposal of old technology must be developed.
5) Finally, a monitoring system should be put in place to establish the impact moving towards sustainable technology is having on energy use. It may be

[58] Ibid

necessary to tighten Nauru's technology standards if the appliances do not prove to be efficient enough, or to loosen the standards if importing energy efficient technology proves to be cost restrictive.

3.3i Investigate Replacement Technology

We recommend that additional research into replacement technologies or alternative strategies as our investigation could not find adequate replacements.

3.4 Energy Conservation through Green Building Standards

The most widely used green building standard is the Leadership in Energy and Environmental Design (LEED) rating system.[59] Each structure built using the LEED system receives a rating (e.g. Certified, silver, gold, or platinum) based on a comprehensive approach.[60] LEED rated buildings reduce energy use by 20 – 50% and water usage by at least 50% outdoors and 30% indoors.[61] The additional cost of building green is estimated to be only $4 per square foot in the U.S., which roughly 2% of building costs.[62]

We believe that significant amounts of energy and capital could be saved through retrofitting existing buildings and by requiring future construction of government buildings to follow LEED standards. Therefore, policies and building code requirements should be put in place requiring these standards to be adhered to.

[59] U.S. Green Building Council. *LEED Buildings.* Available From http://www.usgbc.org/
[60] The Apollo Alliance. New Energy For States. Energy Saving Policies for Governors and Legislators.
[61] "US Department of Energy. Energy Efficiency and Renewable Energy, Federal Energy Management Program. *The Business Case for Sustainable Design in Federal Facilities*. Available at: www.eere.energy.gov/femp/pdfs/bcsddoc.pdf.
[62] Kats, G. *The Costs and Financial Benefits of Green Buildings: A Report to California's Sustainable Building Task Force*. October 2003. Available at: www.cap-e.com/ewebeditpro/items/O59F3259.pdf.

4. Energy Production Using Renewable Energy Technologies

Recommendations:

7. Secure funding to develop direct gird solar panel projects through conventional donors and sources, and attract funding from industrial nations through the Clean Development Mechanism of the Kyoto Protocol.
8. Aggressively pursue the use and active maintenance of passive solar water heating systems using rainwater catchment systems.
9. Conduct Studies using anemometers to determine the suitability of the class III wind region on the island for energy production using wind turbines.
10. Centralize the sewage system to avoid reef contamination and the ensuing decrease in reef productivity. Utilize the sewage to produce biogas that can be used to power the centralized facility. Utilize the "sludge" leftovers from the biogas plant as initial nutrient input for rehabilitation of mined out phosphate areas.
11. Begin planting coconut trees for the production of biofuels.

Nauru has the opportunity to generate significant amounts of energy utilizing renewable energy technologies including, solar panels, wind turbines, biogas, and biofuels as part of the overall energy mix. This section focuses on quantifying the amount of energy that could be produced using two types of solar panel setups, and thus the amount of money that could be saved by burning diesel fuel. It also discusses how to determine whether or not wind turbines would be an significant energy source and quantifies how mush energy could be produced from biogas created through human feces. The section also briefly discusses the need for passive solar water heating utilizing rainwater catchment. Furthermore, it suggests policy options and next steps to expedite the widespread use of these technologies.

Utilizing renewable energy sources has many benefits that will help Nauru transition in to a new energy production era, where the importation of fossil fuel and the resulting energy market vulnerabilities are avoided. Using these types of dispersed systems rather than a central energy production system (i.e. generators) will dramatically reduce greenhouse gas (GHG) emissions, relieve grid congestion during peak hours, and limit sprawling power outages and rolling blackouts. [63]

By connecting renewable energy sources directly into the grid within the domestic sector and utilizing the smart card meters that are soon to be installed, a net metering system can be established where residents can actually produce their own electricity and sell it back to the grid. Net metering has been successfully implemented in more than 35 U.S. states.[64]

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[63] The Apollo Alliance. *New Energy For States. Energy Saving Policies for Governors and Legislators.*
[64] US Department of Energy. *Energy Efficiency and Renewable Energy. Net Metering Policies.* Accessed 03-.21-.07. Available at http://www.eere.energy.gov/greenpower/markets/netmetering.shtml

4.1 Solar

4.1a Solar Panels

Energy Production and Cost Quantification

The following section quantifies the amount of energy that could be produced by using solar panels and the direct cost savings from limited diesel use in the domestic sector. Two scenarios are quantified to give an overall impression of two types of installations that the GoN could implement or encourage for each household: 1) a two-axis tracking 1.2 KW system installed at ground-level (see figure 7), and (2) fixed tilt 5 KW DC (3.85 AC) solar panel systems installed on roofs (see figure 8). To be directly connected to the grid, both types of systems would simply require the appropriate mounting materials, wiring and insulation, labor, maintenance, and inverters to go from DC to AC (see figure 9).

Figure 7. Direct Grid Connected Two-Axis Tracking Solar Panels, 1.2 KW system.

Figure 8. Direct Grid Connected Fixed Solar Panels, 5 KW system. Note that solar panels are only on one half of the roof (i.e. what is shown in image).

Figure 9. Image of a common household inverter.

<table>
<tr><th>Solar Panels</th><th>Details</th></tr>
<tr><td>Qualifying Metrics and Assumptions</td><td>1154 Households (2005 census)
Energy Cost: Aus $ 0.358 / KWh (ADB estimate)
Scenario # 1: Solar Radiation 7.0 kWh/m^2/day for 2-axis tracking 1.2kW system
Scenario # 2: Solar Radiation 5.6 kWh/m^2/day for fixed 5kW system
DC to AC derate factor of 0.77</td></tr>
<tr><td>Energy Production and Cost Savings</td><td>Scenario #1 Two-axis tracking 1.2 kW system and inverter.

Per Household
<table><tr><th>Model Type</th><th>Energy Production</th><th>Cost Savings</th></tr><tr><td>2-axis tracking 1.2 kW system</td><td>~ 2,100 kWh / yr.</td><td>~ Aus $ 770 / yr</td></tr></table>
For Entire Domestic Sector
<table><tr><th>Model Type</th><th>Energy Production</th><th>Cost Savings</th></tr><tr><td>2-axis tracking 1.2 kW system</td><td>~ 2,450,000 kWh / yr.</td><td>~ Aus $ 890,000 / yr</td></tr></table>
Scenario #2 Fixed rooftop 5 KW system and inverter

Per Household
<table><tr><th>Model Type</th><th>Energy Production</th><th>Cost Savings</th></tr><tr><td>Fixed 5 KW rooftop system</td><td>~ 7,000 kWh / yr.</td><td>~ Aus $ 2,500/ yr</td></tr></table>
For Entire Domestic Sector
<table><tr><th>Model Type</th><th>Energy Production</th><th>Cost Savings</th></tr><tr><td>Fixed 5 KW rooftop system</td><td>~ 8,100,000 kWh / yr.</td><td>~ Aus $ 2,9000,000 / yr</td></tr></table></td></tr>
</table>

Barriers to Implementation	Recommended Strategy
(a) Initial Capital Costs	- Tax credits, subsidies, or donor grants to offset initial capital cost
(b) Import tariffs	- Tariff free import license on solar equipment for retail importers
(c) Public willingness to install technologies	- Public awareness campaign
(d) Retailers and installation staff	-Profit Margin set appropriately to energy savings margins to provide retail market and labor incentives
(e) General lack of experience for installation and maintenance.	- Allow Net Metering, so consumers can sell energy back to the grid
	-Attract Industrialized countries through use of the CDM of Kyoto Protocol.

Solar Discussion

The calculations show that most of Nauru's current daytime energy needs could theoretically be easily met through widespread use of solar panels across the domestic sector. However it must be kept in mind that Nauru would still require energy sources at night (wind, diesel, etc.) when solar was not providing the primary energy source. Widespread domestic retrofitting projects of this scale do not currently exist, but that is not a valid reason in of itself to declare that Nauru couldn't begin to move in this direction one project at a time. In fact, the GoN may be able to attract industrialized countries who wish to offset their GHG emissions by giving direct payments for solar applications via the Clean Development Mechanism (CDM) of the Kyoto Protocol. This would give two forms of funding; (1) directly through CDM funding and (2) indirectly through capital cost saved by *not* burning diesel.

In the context of increasing prices (see section 2.4) refined diesel prices on the global market, it makes sense to begin investing in solar panels for energy production, so that energy independence/security can be achieved. The expected lifetime of a solar panel system is on the order of twenty years if properly maintained. By looking at the model for the 2-axis tracking system, we can see how the investment would easily pay for itself during the lifetime of the system. Currently the widespread use of solar is difficult to achieve because of the widely recognized prohibitive costs of the systems.[65] If fuel prices were to increase by between 10 and 20%, which is very possible, then the direct offset costs annually would be roughly $1000/yr, thus leading to a cumulative cost of $20,000 over the lifetime of the system. If widespread implementation were encouraged by the GoN, then economies of scale could be taken advantage of in terms of the solar equipment, installations and maintenance staff. It is well recognized that the costs of equipment are expected to dramatically decline as the private sector moves into a period

[65] The Sydney Morning Herald. *How Solar Ran Out of Puff.* 03/.17/.06. Available at http://www.smh.com.au/news/environment/how-solar-ran-out-of-puff/2007/04/16/1176696757654.html

Formatted: Font: 10 pt, Italic, (Asian) Chinese (PRC) of mass production of solar equipment. The GoN should be poised to transition into a new energy economy where widespread use of solar panels or other photovoltaic technologies are encouraged and become commonplace in both the domestic and public sectors.

Recommendations:

- Calculate costs of solar panel installations based on the EU funded project and utilize the quantitative model presented in this report to gauge if solar panels are a viable option over the course of the lifetime of the system in the context of unstable energy prices due to geopolitics.
- In order to determine the most efficient mix of solar and diesel-generated energy, we recommend using the HOMER model, which is utilized by US utilities and recommended by SOPAC for use in hybrid diesel/solar systems.[66]

4.1b Passive Solar Water Heating

Passive solar heaters reduce further reliance on imported fossil fuels by collecting the sun's energy for heating water for household use. Each passive solar heater is comprised of a collection barrel mounted on a rooftop, with a glazed surface angled to catch the suns rays, or a separate set of solar panels which generates energy to heat the water either internally or eternally. Typical household-use passive water-heating systems provide a 300-liter capacity, adequate for a family of four. Two passive solar heater systems are available: the thermosiphon system and the batch heater (Franklin Energy Services, 2001).

According to the Pacific Regional Energy Assessment 2004, "Nauru has a significant percentage of housing that, from the type of system design and condition, appears to have solar water heaters installed in the late 1980's." Unfortunately, it seems that few of these systems are still working due to lack of maintenance or improper installation.[67] These solar water heaters require regular maintenance because the calcium carbonate in groundwater quickly clogs the heater. This is regrettable, as other island nations have found solar water heaters to be a valuable asset to their country. For example, Barbados has been successful in utilizing passive solar heaters. 32,000 passive solar heaters have been installed in homes and commercial businesses. Each system retails for approximately $US2000 ($AU2660) for a total cost of approximately $US64 million ($AU82 million). This cost to Barbados is offset, however, by the $US6.5 million in savings from the non-importation of fossil fuels, while consumers save $US16 million ($AU8.3 million) from not having to purchase energy to heat their water. Thus within 10 years the capital required for the installation of the passive solar heaters would be

[66] SOPAC. *Hybrid Power Systems and Their Potential in the Pacific Islands.* Aug. 2005.
[67] Pacific Island Renewable Energy Project. *Pacific Regional Energy Assessment 2004: Nauru.* Page 21.

matched by the country's savings in fossil fuel costs alone, with further savings to the government in the years ahead.[68]

The Ministry of Finance of Barbados allowed manufacturers to import materials duty-free in order to cut costs, as well as giving consumers full or partial tax deductions to cover the costs of the heaters.[69] However, due to Nauru's small size, it may be possible to find a donor to cover the costs of the installation or repair of passive solar heaters. Additionally, installations/repair of passive solar heaters reduce the emissions of greenhouse gases, thus allowing the introduction of passive solar heaters to potentially be considered for a GEF or World Bank grant.

Recommendation:

Due to limited data, our team was not able to create reasonable projections on the financial viability of using passive solar water heaters. Therefore, we recommend that energy use by electric water heaters should be quantified and an estimate of the cost to repair and maintain the passive solar water heaters should be created. In addition, possibilities for rainwater catchment systems which feed the passive solar water heaters should be considered. Using rain water rather than ground water would presumably cut down on the need for regular maintenance of the solar water heaters because rain water would not contain the calcium carbonate that is in groundwater and that is responsible for clogging the heaters. A cost benefit analysis should be conducted to determine if the energy and cost savings from the passive solar water heaters makes repairing and/or installing passive water heaters financially viable. Assuming that it does make financial sense to repair and/or install passive water heaters, we recommend that a program be developed around this initiative that could be presented to potential donors.

4.2 Wind

The cost of wind energy, and the optimal turbine technology varies widely depending upon the wind speed and the project site. For most residential systems the cost of taking wind measurements is not necessary.[70] Wind resource mapping, such as that done for Nauru, is sufficient information to predict performance for small wind turbine applications. Based on past wind resource mapping of Nauru, roughly 90% of Nauru is expected to have class 1 and 2 winds. Thus, smaller systems seem to be the most appropriate for much of the island. The cost of buying and installing a small wind energy system typically ranges from about $3,000-5,000 per kilowatt for a grid-connected installation, less than half the cost of a similar solar electric system.[71]

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[68] Sidsnet.org. *Promotion of Solar Water Heating Systems.* Accessed 4.28.07. Available at http://www.sidsnet.org/successstories/11.html
[69] Ibid
[70] American Wind Energy Association. *Small Wind Energy Systems: Frequently Asked Questions.* Accessed 4.29.07. Available at http://www.awea.org/smallwind/faq.html.
[71] US Department of Energy. *Low Wind Speed Technology Goal.* Accessed 4.29.07. Available at http://www1.eere.energy.gov/windandhydro/wind_low_speed.html

Though most of Nauru's wind energy potential lies in the class 1-2 range*, the country's wind resource map indicates that there is a strip of land in the northeastern part of the island that may have Class 3 winds.[72] It is possible for class three winds to be suitable for most utility-scale turbine applications.[73] In order to determine whether or not installing a utility scale wind turbine is economically viable, it is usually necessary to asses the sites wind resources with the use of an anemometer (which are instruments used to measure wind speed over time).[74]

The energy that can be produced using wind turbines is proportional to the cube of the wind speed, so a slight increase in wind speed results in a large increase in electricity generation. For example, a site with an average wind speed of 16 miles per hour will produce generate roughly 50% more electricity than that of a site with an average wind speed of 14 miles per hour (with all other variables being equal).[75] If a specific site is determined to have high class 2 or low class 3 wind, it may be appropriate to install a relatively smaller 10-kW grid-connected system. Systems of this size generally cost costs $35-40,000 to install in the United States.[76] However, it is found that the site produces middle to high class 3 winds a robust turbine could be used.

There are several other factors beyond wind speed that go into determining whether a specific site is economical for a large scale wind turbine. Some factors that need to be considered include soil stability, cost of transmission lines, erosion forces such as salt and sand, and whether the wind blows in conjunction with demand.[77] Given the high initial costs of turbines, and necessity of using the appropriate technology, it is critical that sites be chosen carefully and that potential sites are assessed on the ground.

The wind resource map created for Nauru is helpful in that it gives a general indication of where there might be high wind potential, but any potential utility scale site should be ground truthed by a professional before any investment is made.[78] The following are recommendations and considerations for Nauru to determine whether their class 3 site is suitable for wind turbine applications.

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* NREL's wind speed classification at 50 meters: Class 1= 0.0 to 5.6 m/s, Class 2 = 5.6 to 6.4 m/s, Class 3= 6.4 -7.0 (http://www.nrel.gov/gis/wind.html). Nauru's wind atlas is calculated using 30 meter baselines; thus, qualification for each wind class is roughly 1/2 m/s less than those at 50 meter

[72] Bouisset, S. and Sudres, J. *Nauru Wind Atlas* 11.15.06. Page 17.

[73] National Renewable Energy Library. *Dynamic Maps, GIS Data & Analysis Tools: Wind Maps.* Accessed 4.29.07. Available at http://www.nrel.gov/gis/wind.html.

[74] Danish Wind Industry Association. *Wind Map of Denmark.* Accessed 4.29.07. Available at http://www.windpower.org/en/tour/wres/dkmap.htm

[75] American Wind Energy Association. *Economics of wind energy*. Accessed 4.29.07. Available at http://www.awea.org/pubs/factsheets/EconomicsOfWind-Feb2005.pdf

[76] www.eere.energy.gov/windpoweringamerica/wind_resources.html

[77] Danish Wind Industry Association. *Selecting a Wind Turbine Site.* Accessed 4.29.07. Available at http://www.windpower.org/en/tour/wres/siting.htm

[78] American Wind Energy Association. *Economics of wind energy*. Accessed 4.29.07. Available at http://www.awea.org/pubs/factsheets/EconomicsOfWind-Feb2005.pdf

Recommendations:

1. Install an anemometer (or several) on the area of the island expected to have class 3 wind
    a. Anemometer Height: Ideally an anemometer will be installed at the expected height of the turbine (30-60 meters). However, data collected at a height of 20 meters can generally give a good picture of the expected wind speed at multiple heights. Reliable calculations can be made with 20 meter data to determine expected speeds at greater heights. NRG systems (www.nrgsystems.com) is the most used provider of anemometers, data management software, and towers in the United States.
    b. Duration: The anemometer(s) should be installed for at least a full calendar year in order to determine a sites wind profile. This is because wind speed, duration, and consistency vary daily and seasonally. For a class 3 site to be economically viable it is necessary that the wind profile match the energy demand. For example, if it is found that wind blows at night but peak energy use is during the middle of the day, installing a wind turbine might not be beneficial. Conversely, if it is found that the wind blows the strongest during peak demand, installing a turbine will probably be beneficial
    c. Site Determinants: The most promising sites for wind turbines are generally areas that are hilly, have stable soils, are close to transmission or load (cities, industry, etc…), and are not obstructed by vegetation (trees) or other rigid structures (building). These characteristics should also be considered when installing an anemometer
2. Determine what type of turbine is most appropriate for Nauru
    a. Determine appropriate turbine: The appropriate turbine will depend primarily on wind profile. This should be done with the help of a consultant/professional.
    b. Durability: Turbine durability and resistance to salt and sand may be an important factor on Nauru.
3. Determine cost of transmission lines and altering the electricity grid to accept power from a wind turbine system
4. Other considerations:
    a. Determine/asses the possible negative effects on bird migration patterns

4.3 Biogas

Using biogas technology on Nauru would be an good option because it would limit the amount of sewage dumped near the reef, thus increasing ecosystem productivity, provide methane gas that could be used for either electricity generation or cooking, protect beaches where sewage is currently being dumped, protect the freshwater aquifer on the island from contamination from cesspools, and provide fertilizer that could be used to rehabilitate degraded mining areas. The sewage lines would simply have to be re-routed and the trucks that currently collect sewage from the cesspools would simply have to deliver the waster to a centralized, or a series of centralized facilities where it could be converted to biogas.

An anaerobic biogas digester is an apparatus that facilitates the decomposition of organic matter, via bacteria, in an anoxic environment (see figure 10). As the bacteria decompose organic matter such as human and animal wastes, and plant material, a mixture of gases is produced that can be stored and used for cooking and as fuel for a generator. These systems are being used extensively in India. After digestion occurs, the leftover sludge can be used as fertilizer and has been shown to help expedite the rehabilitation of strip mining sites.[79]

The following quantification table gives the estimate of the potential energy of biogas produced from the waste of 10,000 humans. [80]

Solar Panels	Details
Qualifying Metrics and Assumptions	• 10,000 people • 1 kg of waste per day yielding approximately 0.05 m^3 of usable gas. • An engine requires 0.45 m^3 of gas to produce 0.746 kW per hour.
Energy Production	Per 10,000 people = 828.9 kW/day

Barriers to Implementation	Recommended Strategy
(a) Initial Capital Costs (b) Lack of technical expertise for plant construction (c) Public willingness to install technologies (d) Retailers and installation staff (e) Rerouting sewer lines (unknown infrastructure)	- Public awareness campaign -Attract donor funding to save reef productivity/ promote biodiversity/create energy/rehabilitate mining sites -Construct a centralized, or a series of centralized plants, to process waste to produce biogas

[79] Stehouwer, R. et al. *Nutrient and trace element leaching following mine reclamation with biosolids.* Journal of Environmental Quality 35 (4): 1118-1126 JUL-AUG 2006
[80] Numbers taken from: *3 Meter Biogas Plant*. Published by Vita Accessed 02.24.07. Available at http://www.builditsolar.com/Projects/BioFuel/VITABIOGAS3M.HTM

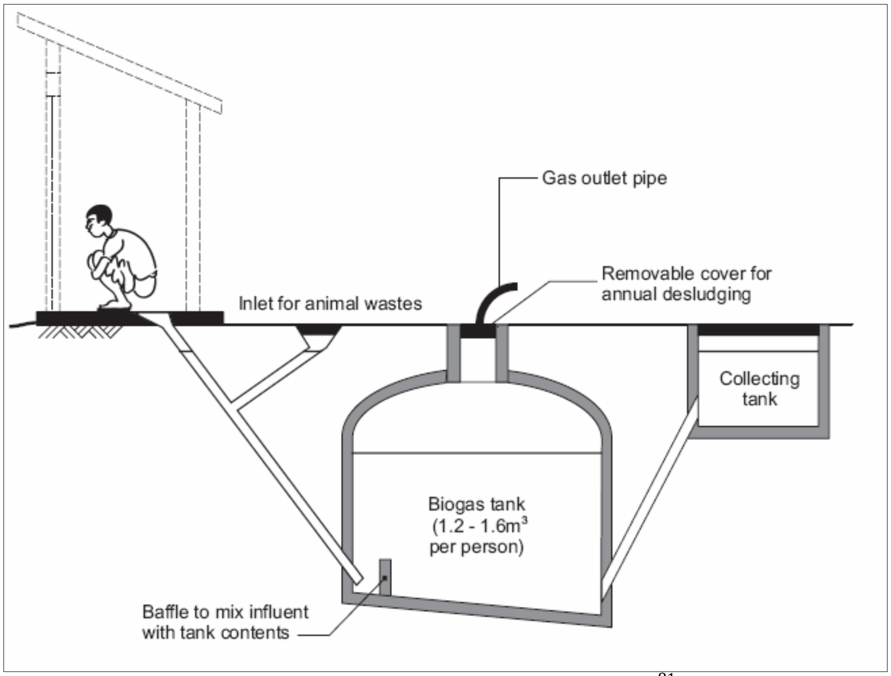

Figure 10. Diagram of a typical household biogas digester. [81]

Although it would be very difficult to achieve these exact numbers, it does show that in theory a significant amount of energy can be produced using biogas from human feces alone. If Nauru was to develop a system of pumping human waste into a centralized biogas facility on the island where human, animal, and organic wastes were conglomerated, then more energy could probably be produced than the previous calculation, and it would be enough to run the facility while providing excess energy to be routed into the grid. Systems like this have been designed and are running in the US states of Washington and Hawaii, and in Indonesia.

4.4 Biofuels

Nauru needs to begin formulating plans for land use after the cessation of phosphate mining operations. The mitigation of abandoned mining areas into plantations for biofuels production is one such option. This would increase energy security, reduce consumption of imported fuels, and create jobs. The use of coconut oil is likely the most geographically and culturally appropriate source in the Pacific islands. Assuming that the soil in these areas is mitigated, Nauru appears to meet the general environmental requirements for such an endeavor. Coconut palms require a suitable annual rainfall ranging from 1200 to 2500 mm/year[82] and Nauru is reported to have averaged 2126mm

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[81]Lboro.ac.uk. *Using Human Waste.* Accessed 2.25.07. Available at http://www.lboro.ac.uk/well/resources/technical-briefs/63-using-human-waste.pdf

[82] Thampan & Darwis (1986) in Waney N & Tujuwale (2002) *Traditional versus intensive coconut production in north Sulawesi.* Sam Ratulangi University 16p

per year over a 77 year period. Furthermore, the cultivation of coconuts and the production of copra is a historically important crop throughout the Pacific and would require very little in the way of capacity building. This is supported by a study in Sulawesi, where it was determined that the traditional monoculture coconut farming systems were by far the most profitable coconut systems.[83] Nauru could seek technical guidance from the FAO and regional organizations such as the Asian and Pacific Coconut Community in order to determine the most appropriate planting strategies and species to utilize.

The FAO reported declining world prices for coconut oils through the 90's so it appears as though production of coconut oil for domestic consumption is more economically viable than production for export.[84] The high cost of importation of diesel fuels further strengthens the argument for domestic production. It has been determined that the local price of coconut oil in the pacific islands is significantly lower than the world price and there is the possibility of coconut oil to be less expensive than diesel (see figure 11).

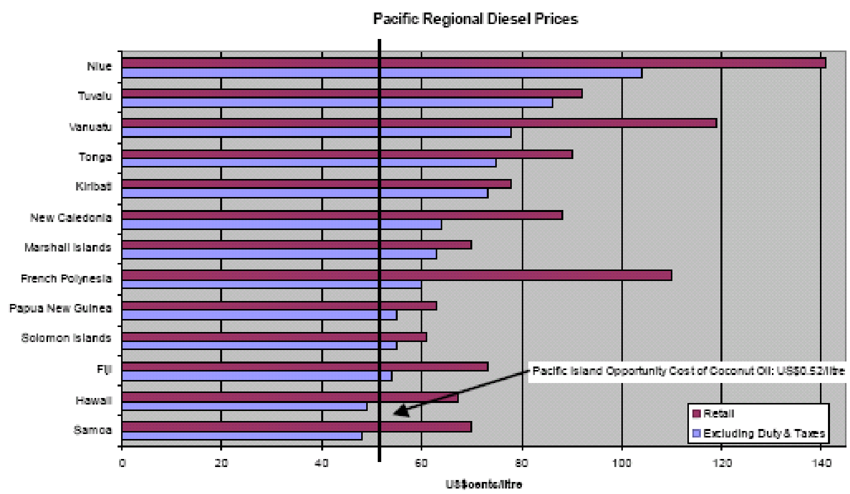

Figure 11[85]: Coconut oil as a biofuel in Pacific Islands

SOPAC estimates after restructuring and replanting of coconut plantations, most Pacific Islands have the potential to provide one third to half of their current diesel imports.[86] A pilot project in Fiji demonstrated that locally produced coconut oil, using a copra dryer and mini oil mill, can successfully be used as a substitute to diesel.[87]

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[83] Waney N & Tujuwale (2002) *Traditional versus intensive coconut production in north Sulawesi.* Sam Ratulangi University 16p.
[84] FAO. *Non-Forest tree plantations.* Forestry department 2001.
[85] Cloin J. *Coconut oil as a biofuel in Pacific Islands.* SOPAC. Page 5.
[86] Cloin J. *Coconut oil as a biofuel in Pacific Islands.* SOPAC. Page 5.
[87] SOPAC. *An Evaluation of the biofuel projects in Taveuni and Vanua Balavu, Fiji Islands.* SOPAC 2006 technical report 392. 29p

The use of coconut oil for use in diesel generators can be accomplished in a few different ways. The oil can be processed into traditional biodiesel and be used as a direct replacement. However, this would require higher costs, infrastructure and technical expertise. Straight coconut oil can be used in diesel engines, although the temperature must be elevated prior to use in order to achieve the correct viscosity. This is generally accomplished through starting the engine on traditional diesel and then switching to the oil after the correct temperature has been attained. The third option is to blend coconut oil with traditional diesel. It is suggested here that Nauru utilize the blending of coconut oil and traditional diesel in a ratio of 30%. At this level of mixing, a number of benefits can be observed. In a study of coconut oil diesel blends, it was shown that at this ratio the cylinder temperatures were 15-35° C cooler, resulted in improved emissions of NOx, CO, hydrocarbons, and particulate matter, while producing the highest level of brake power per specific density among all fuels tested.[88]

[88] Masjuki HH et al. *Performance, emissions and wear characteristics of an indirect injection diesel engine using coconut oil blended fuel.* Proc Instn Mech Engrs 2001 215:393-404

5. Policy Options for Movement toward Energy Sustainability

Recommendations:
12. A phase out of current energy subsidies that encourage fossil fuel consumption.
13. Incentivize renewable energy technologies and conservation measures.

5.1 Political Context of Subsidies

Due to a long history of the subsidization of energy costs, the consumption patterns in Nauru remain remarkably high. Prior to 1990, electricity was provided by the mining operation to all citizens at no cost. This has led to a high usage of air conditioners, electric water heaters, electric water pumps and electrical appliances. Although electricity is no longer free, people continue to consume power to such an extent that domestic electricity bills average between A$200-$300 per month[89]. It is important to note that this is substantially higher than in other Pacific island states similar to Nauru. For example the electricity consumption per household in Nauru is more than double that of Palau, the second highest household electricity user in the Pacific. By the same token, it is more than 30 times greater than household electricity use in urban Kiribati[90]. Prior to mid-2005, domestic customers were charged a rate of AUD 9 cents per kWh as compared to the cost of supply which the consultants have determined to be currently around AUD 30-38 cents[91]. However, domestic customers have only been required to pay a nominal cash amount of AUD$5 per month for their electricity, with the rest funded using Bank of Nauru cheques[92]. This has led to regular cash shortages, and utilities frequently run out of funds to purchase diesel to run the power generators.[93]

5.2 Energy Pricing

Clearly, the current energy pricing scheme is not sustainable and reform has been called for repeatedly. The IEA has stated that those non-OECD countries that continue to provide large subsidies to energy would gain tremendously from their removal as well as from reform of their tax policies[94]. They go on to state that energy subsidies that encourage consumption of fossil fuels rarely yield a net gain in social welfare. Hence, since Nauru is currently subsidizing energy costs for its citizens, there is little financial incentive for citizens to reduce energy use. It has been suggested that a phased subsidy for residential consumers be introduced in with the roll-out of the prepayment system, and every household on Nauru receive a base level of power each month[95]. This subsidy could institute a graduated rate system, allowing financial incentive to conserve.

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89 European Community. *Nauru: Country Strategy Paper and National Indicative Programme for the period 2002-2007.*
90 Asian Development Bank. *Reform of Nauru Phosphate Corporation.* June 2006 p91
91 Nauru's Utilities Sector. *A proposal for reform.* September 2006, p4
92 Nauru's Utilities Sector. *A proposal for reform.* September 2006, p4-5
93 Nauru's Utilities Sector. *A proposal for reform*. September 2006, p3
94 IEA Economic Analysis Division. *Carrots and stickes: taxing and subsidizing energy*. 2006
95 Nauru's Utilities Sector. *A proposal for reform.* September 2006, p16

The introduction of smart cards provides the potential to allow consumers to monitor their consumption in monetary terms, which partnered with education campaigns could result in voluntary conservation.

While educational programs or awareness campaigns may help communicate the necessity of reducing energy use, subsidizing energy use creates a disincentive for energy consumers to reduce their use. One study was conducted on the Hainan Island off the southeast coast of China. The study estimated that Hainan could cut as much as 80% of their energy use in roughly 8 years by implementing stronger demand side management programs.[96] An important part of this savings was "setting electricity prices that reflect the real cost of producing and distributing power during different hours of the day and days of the week."[97]

5.3 Renewable Energy Subsidies

Conversely, subsidies encouraging the growth of renewables are generally recognized to be an effective way of overcoming market barriers to their development and deployment and are increasingly used around the world[98]. It may be possible to direct a percentage of income from the mining operation to the installation and upkeep of renewable energy technologies, in order to ensure energy production continues after the cessation of mining activities. In addition, through increasing demand side energy efficiency, capital will be immediately freed up which could be invested in other renewable energy. Further incentives could be provided to consumers in the form of net-metering, where individual consumers put energy back into the grid. The GoN would actually pay individuals consumers if they produce electricity in excess of their use.

5.4 Technology Transfers

In order to facilitate the move toward energy sustainability, Nauru has the option of introducing mandatory technology transfers and ordinances. These would ensure that only new, energy efficient models of electronic devices would enter the island, as well as compel residents to make use of modern energy efficient heating and lighting systems. For example, in 2006 the city government of Barcelona, Spain, created an ordinance requiring all new buildings to use solar water heaters, while the governments of Cape Town, South Africa, and Rome, Italy worked to integrate minimum energy demand thresholds for the use of solar water heaters (REN 21, 2006).

5.5 Stakeholder Participation

While crafting and implementing such legislation a number of measures should be undertaken in order to ensure overall success and acceptance by the community. First, it is of the utmost importance that community stakeholders be incorporated into every step

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[96] www.orln.gov. *Power to the People: Electricity Planning in Developing Countries.* Page 4. Accessed 3/14/07. Available at http://www.ornl.gov/info/ornlreview/rev28_2/text/irp.htm.
[97] IBID
[98] IEA Economic Analysis Division. *Carrots and stickes: taxing and subsidizing energy*. 2006

of the process to promote a sense of ownership and knowledge of the new technologies and associated policies. This also allows for flexibility in design, so that the needs of the community to be served are most accurately addressed. Unfortunately, there has been a tendency for project ideas to originate from those interested in carrying out the project (donor Countries), rather than from an objective assessment of the need for the project and a careful comparison of the options[99]. The more developed states cannot simply export to SIDS the techniques and computer models developed for other locations and conditions[100], but must recognize the specific constraints imposed by the location and social conditions. For example, external partners that provide aid may be committed to conventional technology for shorter payback, being unwilling to fund high initial investment even though low operating costs are more sustainable in the long run. The long term requirements of said project must also be provided for in terms of legislation, funding, and training. In a study of PV programs, it was recognized that the higher the training budget, the higher the rate of success of the project. Training costs for specific PV projects may be as high as 24% of total cost[101].

[99] Jafar, M. *Renewable energy in the South Pacific – options and constraints.* Renewable Energy 2000. 19:305-9

[100] Perkins RM & Xiang W. *Building a geographic info-structure for sustainable development planning on a small island developing state.* Landscape and Urban Planning 2006 78:353-61

[101] Hiranvarodom, S et al. *A strategic model for PV dissemination in Thailand.* Progress in Photovoltaics: Research and Applications 1999. 7:409-419b

6. Capacity Development and Governance

Recommendations:

14. Focus on capacity assessment and development at the individual, organizational and societal levels *before* the implementation of technologies and projects.
15. Initiate a capacity assessment, housed within GoN, and involving all relevant parties to create Nauruan ownership of a to-be-developed strategy for sustainable energy.
16. Develop appropriate partnerships that bring together university expertise and Nauruan knowledge to design next steps toward a strategy for sustainable energy.
17. Appoint a Director to manage and facilitate Sustainable Energy-related partnerships.
18. Create an oversight and clearinghouse structure to direct the capacity development, technological projects and policy changes involved with a strategy for sustainable energy.

6.1 Capacity Development as Integral to Sustainability

It is a stated National Policy Objective, "To provide opportunities for the population to gain knowledge and skills in order to contribute constructively to the economic development of Nauru".[102] If Nauru is to transition to a more sustainable energy mix, barriers to such a transition must be understood as much more than technical or economic in nature. In order to implement the technical recommendations put forward in this report, there must be educational and informational capacity development within the government and domestic sectors such that the population has the knowledge and skills to contribute to a transition. Capacity development is an important part of proper implementation of new technologies, public policies and economic measures. However, according to the UNDP, the capacity development process must begin long before implementation of technologies; current capacity should drive the shape and size of implementation.[103]

To focus only on the sustainability of technical solutions is to focus on less than half of the equation. The social sustainability of these solutions is critical to the overall sustainability of a transition to new energy mixes. Will solutions be adopted in households? Are there incentives for adoption by households? Is the public sector prepared to support the transition with appropriate maintenance and repair? These are just a few examples of important questions that must be answered. Assessing current capacity is thus a priority before embarking on transitions to sustainable energy. In this section, we present a general discussion of the capacity assessment and development process tailored to the energy sector and based on our technical recommendations.

[102] European Community. *Nauru: Country Strategy Paper and National Indicative Programme for the period 2002-2007.* Page 7.
[103] Sakiko Fukuda-Parr, Carlos Lopes and Khalid Malik (eds). *Capacity for Development*. 2002. Earthscan Publications: London.

According to the UNDP, capacity development needs to be understood and addressed at three levels: individual, institutional and societal:[104]

- **Individual:** This involves enabling individuals to embark on a continuous process of learning—building on existing knowledge and skills, and extending these in new directions as fresh opportunities appear.

- **Institutional:** This too involves building on existing capacities. Rather than trying to construct new institutions, such as agricultural research centers or legal aid centers, on the basis of foreign blueprints, governments and donors instead need to seek out existing initiatives, however nascent, and encourage these to grow.

- **Societal:** This involves capacities in the society as a whole, or a transformation for development.

While technical cooperation and expertise can be important parts of a transition to a more sustainable energy economy in Nauru, it is important that the capacity assessment and development process be driven *internally*. We would like to highlight the conclusion of the UNDP that "capacities exist in developing countries and need to be developed… development strategies do not have to, and indeed should not, be imported from outside."[105] Furthermore, regarding the development of cooperation for technical assistance for capacity, "the main objective of technical cooperation should be to contribute to the utilization and expansion of local capacities."[106] These sorts of principles inform a new paradigm for capacity development as understood by UNDP:

[104] Sakiko Fukuda-Parr, Carlos Lopes and Khalid Malik (eds). *Capacity for Development*. 2002. Earthscan Publications: London. p9.
[105] Carlos Lopes and Thomas Theisohn. *Ownership, Leadership and Transformation*. 2003. Earthscan Publications: London. pXII.
[106] Carlos Lopes and Thomas Theisohn. *Ownership, Leadership and Transformation*. 2003. Earthscan Publications: London. pXII.

	Current paradigm	New paradigm
Nature of development	Improvements in economic and social conditions	Societal transformation, including building of "right capacities"
Conditions for effective development cooperation	Good policies that can be externally prescribed	Good policies that have to be home-grown
The asymmetric donor-recipient relationship	Should be countered generally through a spirit of partnership and mutual respect	Should be specifically addressed as a problem by taking countervailing measures
Capacity development	Human resource development, combined with stronger institutions	Three cross-linked layers of capacity: individual, institutional and societal
Acquisition of knowledge	Knowledge can be transferred	Knowledge has to be acquired
Most important forms of knowledge	Knowledge developed in the North for export to the South	Local knowledge combined with knowledge acquired from other countries—in the South or the North

Figure 12[107]: Moving toward a new paradigm for Capacity Development

We take the perspective of this new paradigm regarding Nauru's transition to a more sustainable energy economy and believe that capacity assessment and development, along with technical cooperation, should not be a supply-driven process, but rather a demand-driven one.[108] This focus means that national ownership over the capacities and technologies involved in Nauru's transition are of utmost importance, where ownership implies: "a fully participatory process of engagement with citizens, civil society, academia, trade unions, the private sector, etc., in addition to different government agencies."[109]

6.2 Technical and Educational Capacity Building

Due to the geographic location and industrial capability of Nauru, the technologies involved in transitioning to a more sustainable energy mix are going to have to be imported. However, the capacity development and educational strategies needed to secure sustainability of these technologies should not be. Rather, they should be based on existing and nascent capacities within Nauru.

Technical cooperation is still frequently criticized for:[110]

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[107] Sakiko Fukuda-Parr, Carlos Lopes and Khalid Malik (eds). *Capacity for Development*. 2002. Earthscan Publications: London. p20.
[108] Stephen Browne (ed). *Developing Capacity through Technical Cooperation*. 2002. Earthscan Publications: London. pVII.
[109] Stephen Browne (ed). *Developing Capacity through Technical Cooperation*. 2002. Earthscan Publications: London. pIX.
[110] Sakiko Fukuda-Parr, Carlos Lopes and Khalid Malik (eds). *Capacity for Development*. 2002. Earthscan Publications: London. p5.

- **Undermining local capacity:** Rather than helping to build sustainable institutions and other capabilities, technical cooperation tends to displace or inhibit local alternatives.

- **Distorting priorities:** The funding for technical cooperation generally bypasses normal budgetary processes, escaping the priority-setting disciplines of formal reviews.

- **Choosing high-profile activities:** Donors frequently cherry-pick the more visible activities that appeal to their home constituencies, leaving recipient governments to finance the other routine but necessary functions as best they can.

- **Ignoring local wishes:** The donors pay too little attention either to the communities who are supposed to benefit from development activities, to the local authorities, or to NGOs, all of whom should comprise the foundation on which to develop stronger local capacity.

- **Fixating on targets:** Donors prefer activities that display clear profiles and tangible outputs. Successful capacity development, on the other hand, is only intrinsically included.

In order to avoid these concerns, it is important that the capacity development process be carefully designed in lock-step with technological implementation process, keeping in mind the aforementioned principle of national ownership. In Figure 13 below, the UNDP process for capacity development is outlined. The concern of this report is only with the initial stages (Steps 1 and 2). Our goal is to provide suggestions and resources for the initiation of a capacity development strategy to complement the technical recommendations put forth elsewhere in this document.

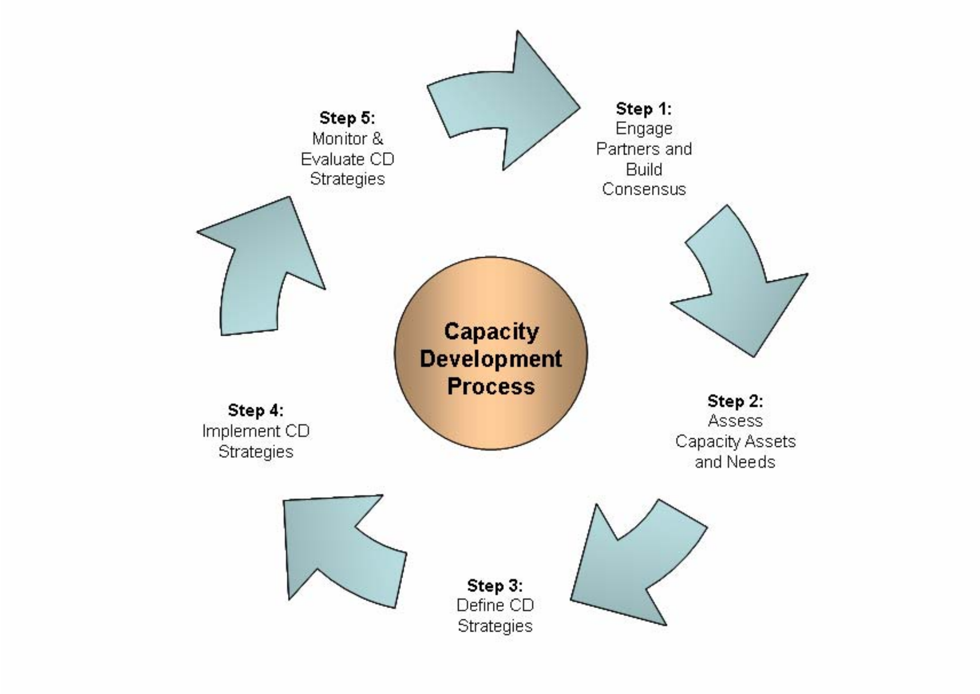

Figure 13[111]: The UNDP Capacity Development Process

There are excellent UNDP resources for Capacity Assessment and Development. Of particular importance in the creation of an energy transition strategy, the GoN might find the "Capacity Assessment Supporting Tool"[112] and the accompanying step-by-step "Capacity Diagnostics Methodology User's Guide"[113] located online on the UNDP's Capacity Development homepage (http://www.capacity.undp.org/). These resources represent the theoretical framework for capacity development described above and would allow the GoN to begin assessing critical actors, competencies, capacities and deficiencies related to the energy economy (both policy and infrastructure).

Chapter X of the Barbados Programme of Action notes the importance of governance and capacity building to ensure steps toward sustainable development occur now and in the future, particularly in the realm of environmental resource management. Therefore, the integration of environmental interests into national policy and decision-making is imperative to make sure that the principles of sustainability direct future development (BPoA X: 46). In the case of developing capacity for renewable energy technologies and energy efficiency, the strengthening and expanding of administrative capacity, the creation of a National Energy Strategy touching upon all levels of government, and the inclusion of the public through public education programs will accelerate Nauru's

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[111] UNDP Capacity Development Group. *Capacity Diagnostics Methodology: Users Guide.* 2006. Bureau for Development Policy.

[112]http://www.capacity.undp.org/index.cfm?module=Library&page=Document&DocumentID=6021

[113]http://www.capacity.undp.org/index.cfm?module=Library&page=Document&DocumentID=6022

changeover from fossil fuels to renewable energy sources. We touch briefly on some suggestions for governmental capacity and public capacity below:

Government

According to the Nauru National Sustainable Development Strategy (NSDS), there have been key institutional changes involved the establishment of the Development Planning and Policy Division (DPDD) in 2005 and the Aid Management Unit (AMU) in 2003. The DPPD "will be largely responsible for coordinating planning efforts at the national level, in particular monitoring the implementation of the NSDS."[114] AMU is responsible for coordinating developing assistance received from development partners, and will also appraise and approve all projects intended for external assistance through the development-planning framework. This assures that all projects funded under external assistance are supportive of Nauru's national priorities.[115] Both the DPDD and AMU should be involved in the capacity development efforts for a transition to more sustainable energy. Further, their involvement in an oversight mechanism for the transition process is encouraged.

Public

After assessment of capacities and based on the findings of such an assessment, a public awareness and education campaign should be developed to help the general public understand the necessity and process for switching to energy efficient appliances and using renewable technologies. Involvement of all sectors of civil society should be emphasized. Of particular importance, would be the involvement of Nauru Island Association of Non-Governmental Organisations (NIANGO)[116], because as noted in the next section, funding is sometimes only available for projects that are initiated by NGOs.

These, however, are only initial ideas. A proper assessment of capacity should be conducted and a corresponding capacity development process created.

6.3 Possible Partnerships to Develop Capacity Assessment and Technical Solutions

It is essential for Nauru to develop strong partnerships with diverse agencies and institutions globally that can support their transition towards sustainable energies with financing, consultancy, capacity development and education, and innovative planning. These relationships can be forged with UN agencies, Universities, Non Governmental Organizations (NGOs), and private industry. The position of "Director for Sustainable Energy Partnership" might be created to manage communication and facilitate such partnerships.

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[114] NSDS p12.
[115] NSDS p12.
[116] European Community. *Nauru: Country Strategy Paper and National Indicative Programme for the period 2002-2007.* Page 15.

UN Agencies

The GEF-UNDP Small Grants Programme (SGP) is a potential source of funding for further research into sustainable energy development on Nauru. The grants would allow for projects totaling USD 50,000 (averaging USD 20,000). In order to receive grants an in-country nongovernmental organization (NGO) or community-based organization (CBO) must be involved in the project application. Coordination with NIANGO would seem to be appropriate.

Projects in the initial capacity assessment phase would fall under Operational Program 5 “Removing Barriers to Energy Conservation and Energy Efficiency” which includes activities such as:[117]

- participatory, community-based assessments of local energy use, resources, and alternatives
- energy audits of homes, buildings, hotels, and factories linked to advocacy and training about energy efficient responses
- capacity-building and awareness-raising activities about climate change and its repercussions at the local level, incorporating local knowledge about climatic history and patterns
- capacity-building and awareness-raising activities about energy efficiency
- advocacy to remove subsidies to inefficient and polluting sources of energy

Projects in the implementation phase of alternative energy development would fall until Operational Program 6 “Promoting the Adoption of Renewable Energy by Removing Barriers and Reducing Implementation Costs” which includes activities such as:[118]

- demonstration projects involving the introduction of appropriate, renewable solar technologies at the community level: solar pumps for water purification and irrigation, as well as solar energy for cooking, heating, and electricity
- demonstration projects involving wind-generated energy for community and municipal needs
- biogas demonstration projects in appropriate contexts where there are incentives for sustainability
- collaborative community/academic research and development in order to produce low-cost, sustainable energy options

Universities

Just as this report has been prepared within a partnership between the GoN and Yale University graduate students (via the UN Permanent Mission) the authors recommend the possibility of creating other relevant partnerships with universities. Universities and their

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[117] Global Environment Facility. *Small Grants Program: Climate Change.* Accessed on 4.01.07. http://sgp.undp.org/index.cfm?module=projects&page=FocalArea&FocalAreaID=CC

[118] Global Environment Facility. *Small Grants Program: Climate Change.* Accessed on 4.01.07. http://sgp.undp.org/index.cfm?module=projects&page=FocalArea&FocalAreaID=CC

relevant departments can provide significant amounts of original contextual research that can help Nauru develop specific projects. The GoN should actively promote information exchange and project development by establishing relationships with academic institutions. The GoN can provide guidelines for project development in the areas of architecture, environmental planning, policy formulation, and numerous other areas, which can be used as projects for graduate students, thus providing the GoN with free labor and professional products that can be help achieve Nauru's sustainable development goals. A short list of relevant programs and departments at the leading institutions within the United States is included as Appendix 2.

6.4 Potential Governance Structures for Sustainable Energy Transition

Context

Even for a small nation like Nauru, ad hoc programs and policies without some sort of centralized administration and governance will result in inefficient implementation and ultimately to less sustainable practices. What is needed is large-scale implementation of infrastructure and institutional development based on proven models and adaptive governance strategies. It is a principle goal to develop capacity within Nauru to design and implement renewable projects and not perpetuate the dependence on foreign consultancies. We propose that a centralized organization be created that can serve as a project creation and implementation clearinghouse (see Figure 14). The following is a description of how this organization would essentially function at a National Level within Nauru.

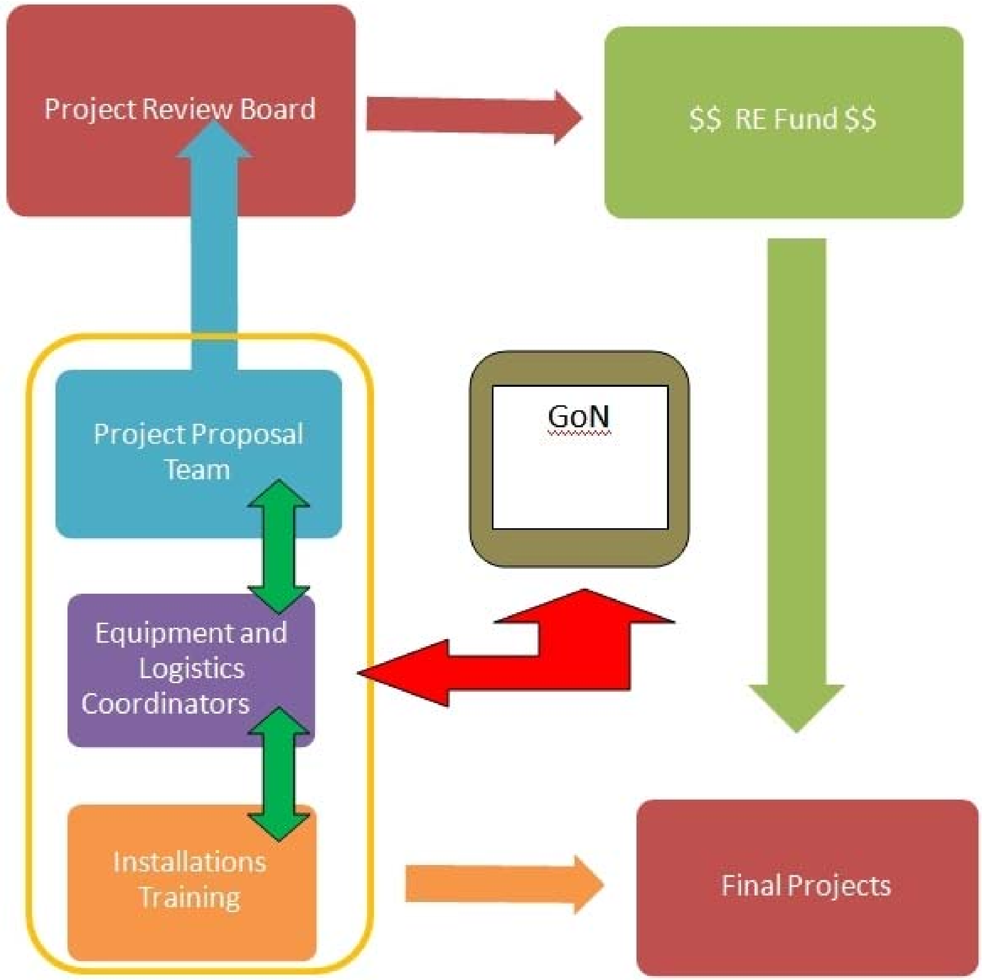

Figure 14: High Level Structure of Governance Mechanism

Initial Capital Investment

Significant initial capital investment is needed to create a functioning organization that can organize renewable energy projects for the nation. This type of organization is a prerequisite to having a functioning system to implement large-scale renewable energy projects. In addition to the creation of a dedicated Renewable Energy Fund, four interconnected bodies will have to be created simultaneously to get the organization off the ground and running: (1) The Project Review Board, (2) the Project Proposal Team, (3) the Equipment and Logistics Coordinators, and (4) the Installations Training facility, which should all be in one office or facility in order to promote economies of scale, information sharing, and teamwork.

Renewable Energy Fund and Project Review Board

A renewable energy Fund should be created that could serve as a functioning working account for renewable energy projects for Nauru. In addition to finding donors who can provide direct funding, revenues from the Phosphate industry, once it is functional, should be diverted to this fund to develop island financial capacity for renewable energy. A multi-stakeholder board of directors (Project review Board) should be appointed to manage the funds and to determine which projects are worth funding. This model could be implemented to catalyze access to GEF, UNDP and WB funds.

Project Proposal/Development Team

The Project Proposal Team would serve the essential function of drafting project proposals to be submitted to the Project Review Board. The team would work independently as a think tank, but also hand in hand with the Equipment and Logistic Coordinators and the Installations Training Staff in order to ensure that projects are possible in the needed context and that infrastructure, timeline, equipment, staff, and pricing incorporated into the proposals accurately reflect available resources. The Project Proposal Team should have representatives and workers from the local communities. These individuals would be trained initially by consultancies focused on project design and grant writing. Universities and NGOs may be able to offset the initial capital costs by providing this training.

Equipment and Logistics Coordinators

The department titled Equipment and Logistics Coordinators would primarily be staffed by local people and would serve the function of developing working relationships with the following: renewable energy consultancies that are needed for specific or difficult projects, vendors of renewable energy equipment, and coordinating research and intellectual efforts with projects on the ground. Furthermore, they would serve the role of making sure the proper equipment was ordered and the implementation and long-term system maintenance staff were available and dedicated to specific projects.

Installations Training

This department would function as a training center for professionals to aid in the set up and maintenance of renewable energy technologies like solar, biogas, and wind (i.e. electricians, importers, maintenance staff, and managers). Initially this department could be set up to train larger numbers of staff and over time would diminish to train only the needed amount of staff to keep numbers from declining and aid in the continuous implementation of projects.

The First Steps

The first steps to creating an organization dedicated to training staff and writing proposals to implement renewable energy projects on the ground would to be to secure funding to commence the following:

1. Designate a geographical location/facility site.
2. Create a renewable energy fund that can be administered by a newly created Board of Directors, who will also serve as the Project Review Board.
3. Hire a highly reputable consultancy to set up the facilities and train the Project Proposal Team, Equipment and Logistic Coordinators Dept., Installations Training Center. It is important that in addition to creating a robust organization that is transparent and professional, that the consultant should agree to the terms and lay out clear strategies that as they are training the first generations of staff and creating the first generation of projects, that they will also train the next generation of trainers. The consultants should be kept on until at least two full classes of trainees have been fully trained and multiple successful projects have been completed.

Appendix 1: Contacts

Further information about Agilent's light-emitting diode products is available at www.agilent.com/view/led.

Contacts for the Barbados Promotion of Solar Water Heating Systems are listed below:

Mr. James Husbands
CEO, Solar Dynamics,
Grazettes Industrial Estate, Saint Michael, Barbados
Tel.: (246) 425-1540
Fax: (246) 424-8779
E-mail: solardynamics@sunbeach.net

Mr. Peter Hoyos
CEO, SunPower, Searles Factory,
Christ Church, Barbados
Tel.: (246) 428-0634
Fax: (246) 428-0740
Web site: www.sunpowR.com

Mr. Vincent McClean
CEO, AquaSol Components Ltd.
Block A7, Grantley Adams Industrial Park,
Christ Church, Barbados
Tel.: (246) 428-0255
Fax: (246) 428-1719
Web site: www.aquasolonline.com

Prof. Oliver Headley, Director, Centre for Resource Management
and Environmental Studies,
University of the West Indies,
Cave Hill, Barbados
Tel.: (246) 417-4339
Fax: (246) 424-4204
E-mail: oheadley@hotmail.com

Agilent Technologies, Inc.
Literature Service
Ref.-Nr.: PRSP0100408
Postfach 2260
D-35532 Wetzlar

Fax: +49 (0) 64 41 / 92 46 46
E-mail: info@promotionteam.de

Appendix 2: Contact Information for University Partnerships

Duke University, Nicholas School of the Environment and Earth Sciences
Box 90328 Duke University
Levine Science Research Center
Durham, NC 27708, USA
Phone: (919) 613-8000
Fax: (919) 684-8741
http://www.nicholas.duke.edu/

Harvard University Graduate School of Design
48 Quincy Street
422 Gund Hall
Cambridge, MA 02138, USA
Phone: (617) 495-5453
Fax: (617) 495-8949
http://www.gsd.harvard.edu/index.html

Stanford University Interdisciplinary Graduate Program in Environmental and Resources
397 Panama Mall
Mitchell Building, Rm. B52
Stanford, CA, 94305-2210, USA
Phone: (650) 723-6117
Fax: (650) 725-4139
nelsondn@stanford.edu
http://iper.stanford.edu/index.php

University of California Berkeley

Department of Environmental Science, Policy, and Management
137 Mulford Hall #3114
Berkeley, CA 94720-3114, USA
Phone: (510) 643-7430
Fax: (510) 643-5438
espm_reception@nature.berkeley.edu
http://espm.berkeley.edu/

College of Environmental Design
232 Wurster Hall #1800
Berkeley, CA 94720-1800, USA
Phone: (510) 642-4942
Fax: (510) 643-5607
http://www.ced.berkeley.edu/#

Energy and Resources Group
310 Barrows Hall
University of California
Berkeley, CA 94720-3050, USA
Phone: (510) 642 - 1640
Fax: (510) 642 - 1085
http://socrates.berkeley.edu/erg/index.shtml

University of California, Santa Barbara, Donald Bren School of Environmental Science & Management
2400 Bren Hall
University of California, Santa Barbara
Santa Barbara, California 93106-5131, USA
Phone: (805) 893-7611
Fax: (805) 893-7612
http://www.bren.ucsb.edu/

University of Michigan, School of Natural Resources and Environment
Dana Building
440 Church Street
Ann Arbor, Michigan 48109-1041, USA
Phone: (734) 764-6453
Fax: (734) 936-2195
http://www.snre.umich.edu/index.php

Yale School of Forestry and Environmental Studies
205 Prospect Street
New Haven, CT 06511, USA
Phone: (203) 432-5100
Fax: (203) 432-5942
http://environment.yale.edu/

Appendix 3: Physical Geography and Environment

Nauru is a remote island situated 41 km south of the equator about halfway between Honolulu and Sydney (0º 32' S. latitude and 166º 56' E. longitude) with a total land area of 21 km^2 and an exclusive economic zone (EEZ) of 320,000 km^2 (see figure 1). There is a fertile strip between 150 and 300m wide that circles the island.[119] Temperatures on the island range from 22º C to 35º C year round, there are no cyclones, and annual rainfall is stochastic, averaging 2098mm per year between 1894 and 2001 with a range of 4310mm.[120,121] The raised coral island is divided into two distinct plateau areas named "bottom side" and "topside", with the latter being roughly 30 meters higher on average.[122] Topside reaches an altitude of about 56 meters and has suffered serious land degradation from more than a century of mining of the high-grade tricalcic phosphate rock (phosphate mining); leaving the terrain infertile, void of population, and ridden with jagged coral pinnacles standing 15 meters high.[123] It is estimated that 90% of the island has been mined out.[124] The erosion and siltification caused by the interior mining coupled with the dumping of sewage near the reef has severely damaged the reef ecosystem and continues to limit biological productivity.[125] It is estimated that the reef productivity is only 40% of normal.[126] The only significant permanent freshwater resource is the groundwater lens, and this source has been contaminated by leachates and human waste from mismanagement of solid wastes and septic tanks.[127]

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[119] European Community. *Nauru: Country Strategy Paper and National Indicative Programme for the period 2002-2007*. Page 8.
[120] Pacific Regional Energy Assessment 2004. *An Assessment of the Key Energy Issues, Barriers to the Development of Renewable Energy to Mitigate Climate Change, and Capacity Development Needs for Removing the Barriers*. Nauru National Report Volume 7.
[121] SOPAC. *Nauru at a Glance.* Accessed 03.12.07. Available at http://www.sopac.org/tiki/tiki-index.php?page=Nauru+at+a+Glance
[122] Pacific Regional Energy Assessment 2004. *An Assessment of the Key Energy Issues, Barriers to the Development of Renewable Energy to Mitigate Climate Change, and Capacity Development Needs for Removing the Barriers*. Nauru National Report Volume 7.
[123] European Community. *Nauru: Country Strategy Paper and National Indicative Programme for the period 2002-2007*.
[124] NSDS p. 16
[125] Pacific Regional Energy Assessment 2004. *An Assessment of the Key Energy Issues, Barriers to the Development of Renewable Energy to Mitigate Climate Change, and Capacity Development Needs for Removing the Barriers*. Nauru National Report Volume 7.
[126] NSDS p. 9
[127] SOPAC. *Nauru at a Glance.* Accessed 03.12.07. Available at http://www.sopac.org/tiki/tiki-index.php?page=Nauru+at+a+Glance.

Figure A1: Satellite image of Nauru courtesy of google.com/maps.

Social Context and Political Structure

Nauru had an estimated population of 10,065 persons when the 2005 census was taken, of which approximately 75% are indigenous Nauruan.[128] The island is divided into 14 administrative districts based on geography and tribal affiliation. These districts are further subdivided into 8 constituencies that democratically elect 18 members to the Westminster parliamentary system for 3 year terms, who in turn elect the president.[129] The parliamentary democracy is divided into two levels, where the parliament is responsible for national and international matters and the National Island Council (NIC) is responsible for local government and public services. Nauru became a member of the Commonwealth and the United Nations in 1999.[130]

Economics and Industries

Phosphate has been exported from the country since 1907 with an interruption between1942 and 1947 during World War II. Soon after gaining independence in 1968, the Nauru Phosphate Corporation was established and took over mining operations which had been previously undertaken by a British company followed by a British/Australian/New Zealand consortium. This led to Nauru becoming one of the

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[128] NSDS p. v

[129] European Community. *Nauru: Country Strategy Paper and National Indicative Programme for the period 2002-200*7. Page 8.

[130] NSDS p. v

wealthiest small island nations in the world in terms of GDP per capita (~A$5,000, 1995).[131] Nauruan phosphate is of the highest grade in the world and continues to be Nauru's primary major foreign-exchange earner[132]. The phosphate industry peaked during the mid 1980's with an export value of roughly $120 million (AU).[133] The remaining phosphates are estimated to last between 5 and 15 years, but there is hope of significant economic productivity coming from secondary mining and through the sale of the high-grade pinnacle rocks.[134,135]

Nauru has significant fishery resources within the EEZ. However, this sector is underdeveloped. In 2000, international fishing licenses sold to the US, Japan, Taiwan, and the Philippines amounted to a total revenue of A$8.5 million. The Nauru Fishery and Marine Resources Authority purchased a long-line fishing vessel in 2000 and gained approval to purchases another, thus making a significant contribution to the domestic fisheries sector.[136] Reported fishing outings aimed at harvesting sashimi grade tuna to ship to Japan have been relatively successful and have generated total revenues of between A$10,000 and A$20,000 per shipment.[137]

Unfortunately, the fiscal and economic situation for Nauru has steadily deteriorated since the 1990's; primarily due to the reduction in the ability of the phosphate industry and external assets to support the national economy because of rampant mismanagement and corruption. Nauru's economy is driven by the public sector, where almost every aspect of economic activity is affected or driven by either the central government or its instrumentalities.[138]

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[131] European Community. *Nauru: Country Strategy Paper and National Indicative Programme for the period 2002-200*7. Page 9.
[132] NSDS p. v
[133] European Community. *Nauru: Country Strategy Paper and National Indicative Programme for the period 2002-200*7.Page 8.
[134] European Community. *Nauru: Country Strategy Paper and National Indicative Programme for the period 2002-200*7.Page 9.
[135] Personal Communication with Ambassador Marlene Moses (02/24/07)
[136] European Community. *Nauru: Country Strategy Paper and National Indicative Programme for the period 2002-200*7. Page 9.
[137] NSDS p. 8
[138] NSDS p. 13