DRAFT FOR DISCUSSION

Towards integrated sustainable energy management in NMMU

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Introduction

The NMMU is committed to responsible energy management in order to meet its responsibility and commitment to reducing CO_2 emissions, increased energy efficiency, energy conservation and increased renewable energy supply. The university is motivated by two imperatives: an economic imperative, and a sustainability imperative.

The economic imperative

The value of green buildings

A general misconception exists that 'green' buildings are more expensive than conventional ones. A recent US study (Morris 2007) indicates that most buildings with a modest green rating cost no more to construct than conventional buildings, and that even those with a high rating cost a mere 2-6% more than conventional buildings. In an analysis of a paired sample of 10 000 conventional and green buildings, Eicholds et al. (2008) concluded that green buildings command up to 6% higher rental rates and sell for 16% more than conventional buildings. Employees in environmentally friendly buildings are more productive (http://www.epa.gov/iaq) and green buildings are good for an organization's corporate image and make it attractive to prospective employees, clients and investors because of an association with social and environmental responsibility. Sustainable buildings depreciate at a slower rate leading to higher property values in the eyes of investors. After studying 33 buildings with green ratings, California's Sustainable Building Task Force concluded that the benefits and operational savings of green buildings exceeded their construction costs by a factor of 10. It therefore makes economic sense to retrofit conventional buildings.

A 2008 study by Delloitte found that the main benefits of green retrofitted buildings were the brand value, followed by employee comfort, attractiveness to employees, and their wellness and productivity (Fig. 1). In the academic environment, sustainability studies are amongst the fastest growing academic disciplines, and many students are attracted to institutions on the basis of their commitment to sustainability (http://www.thetimes.co.za/Careers/Article.aspx?id=808687).

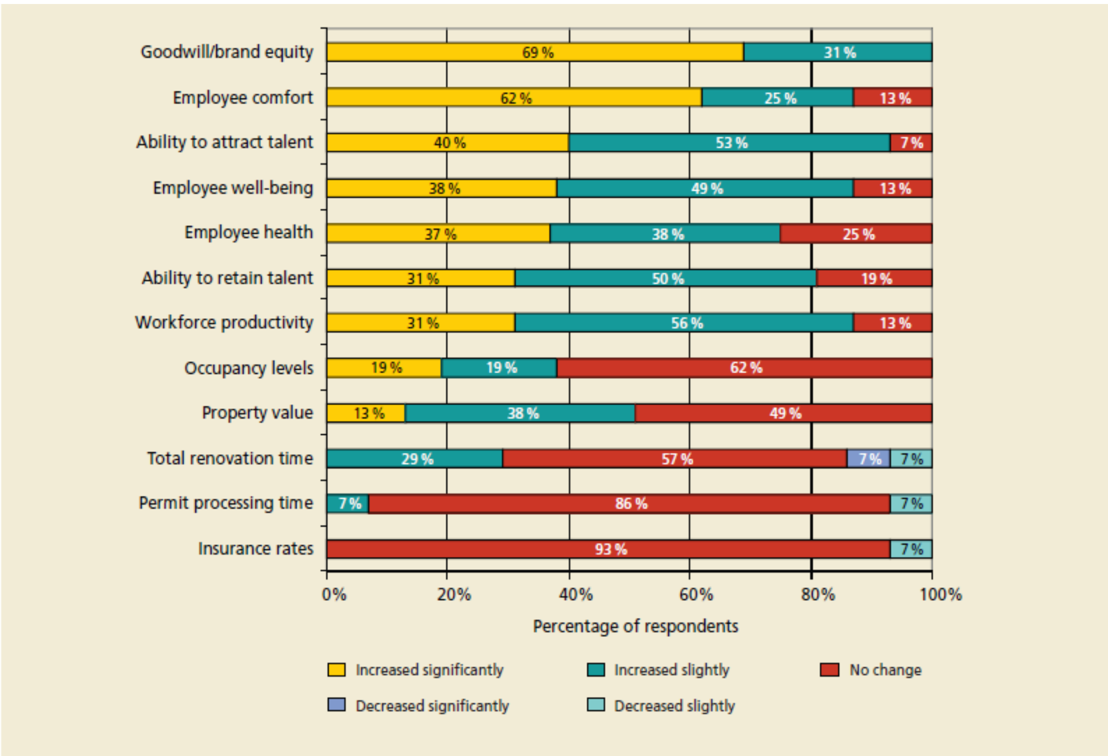

Figure 1. The economic impacts of green retrofit buildings (from Deloitte 2008)

Energy savings

The benefits of going for a green campus are many, an estimated savings of approximately 30% can be achieved by improved design and management practices (DME 1998). For example the BP head office at the V&A Waterfront (a green campus-style building), uses 192kWh a square metre a year compared to a conventional building its size, which uses over 330kWh. (Barnes 2008) Energy efficiency has been identified as the most cost effective way of meeting demands of sustainable development (DME 2005). The most significant legislation regarding energy efficiency is the draft Energy Efficiency Strategy (2004) which encourages sustainable energy development and energy use through efficient practices. A national target for energy savings, of at least 12%, has been set and must be achieved by 2015 (DME 2005).

To implement energy saving strategies specifically as it relates to electricity, it is important to understand the Energy Tariff which is used to determine the electricity account. Over and above certain fixed costs, the main cost determining criteria are:

- the Maximum Demand (kVA – kilo Volts Ampere) measured in half hourly intervals and applied individually to the various campuses.
- the energy consumption units used as measured in kWh (kilo Watt hours): The kWh used is multiplied with a fixed consumption usage charge rate as applied per site (and not per institution), in order to calculate the consumption cost.

The Maximum Demand tariff is calculated from a zero base each month by the energy supplier. This tariff calculation uses the highest energy demand (over a period of a half hour) during the month as the bases of calculating the Maximum Demand cost. An additional problem for a multi campus environment is that of multiple Maximum Demand accounts as apposed to a single campus environment generating only one Maximum Demand account/cost. Obviously this relates to a substantial cost differentiation.

Because the energy supplier therefore needs to provide this maximum amount of energy on demand, this impact negatively on the supplier's costing model. The user is therefore charged a premium for the peak kVA generated. For this reason the multiple Maximum Demand accounts of the NMMU has resulted in this component being roughly one third of the NMMU's total electricity account.

Given that the electricity budget provision for 2009 is R15M, with one third being R5M, a key energy saving strategy must be to manage the Maximum Demand tariff in real time. In addition, ESKOM has informed users of pending legislation which will endeavour to reduce overall Maximum Demand by 25% through a process of implementing a penalty scale and the NMMU therefore needs to be proactive in meeting this reduction target.

Demand side management as basically explained above can be achieved by the use of Ripple control and real time evaluation and control via the Johnson Controls Building Management System (JCBMS). In doing this, the peak power consumption (kVA's) is minimized by ensuring optimal energy usage wherever possible and enforcing energy factor correction options. This strategy will significantly reduce the R10M energy consumption cost as well.

The sustainability imperative

Although South Africa, unlike OECD countries, is not obligated to reduce its greenhouse gas emissions under the Kyoto Protocol, but has a commitment to mitigate its Carbon emissions. The country is a significant contributor to greenhouse gas emissions. Our per capita emissions is amongst the highest in the world, and the amount of CO2 produced per unit GDP (in US$, corrected for purchasing power) is the second highest in the world, more than three times that of Brazil and twice as high as that of India (Fig 2).

Electricity accounted for 45% of South Africa's greenhouse gas emissions in 2003, almost as much as transport and industry combined. Without any mitigation South Africa's emissions are predicted to quadruple by 2050. This will be unacceptable to the international community and bad for the economy. The Scenario Building Team concluded that, in order to reach for the goal of reduced emissions by 2050, South Africa has to invest in four key strategies: 1) Start now by doing what is possible within current policy, albeit with significant effort. This includes: "energy efficiency, especially in industry; electricity supply options; Carbon Capture and Storage (CCS); transport efficiency and shifts; and people-oriented strategies, supported by awareness". 2) Scale up from household to regional level; 3) use market forces such as taxes and incentives to change economic behaviour, and 4) innovate by a) developing new technologies; b) identifying new energy resources; c) changing social behaviour; and d) transition to a low-carbon economy.

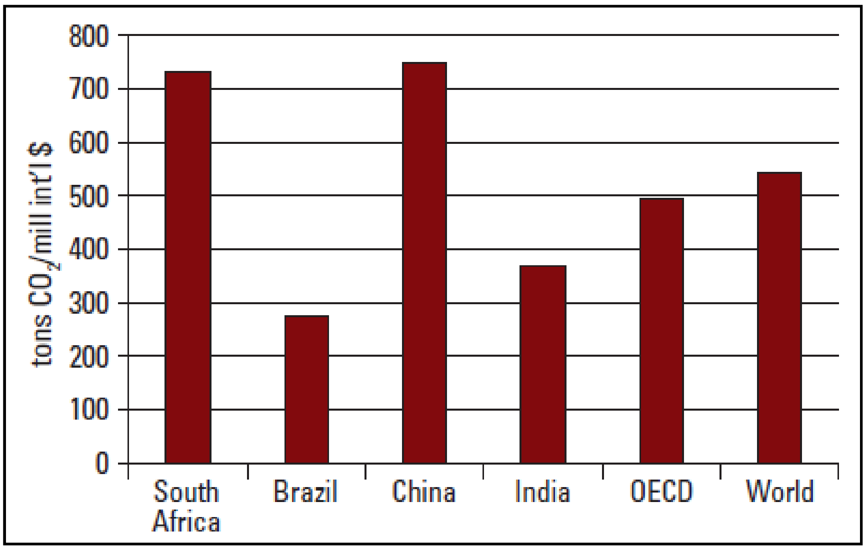

Figure 2 Emissions intensity, in terms of emissions produced per million US$ on a power purchasing parity basis (source: Scenario Building Team, 2007)

The roles of universities

It is in the fourth category (meeting goals through innovation) where universities must voluntarily lead by example. Universities can be compared to small cities or large tourism complexes or hotels in terms of their energy consumption and waste production, and are microcosms of society in terms of inequalities, potential for conflict, and need for economic viability. The international Talloires Declaration is the first official international statement of over 350 universities undertaking to provide environmental education and implement sustainable practices on campuses. Five universities in South Africa are signatories, namely Rhodes University, University of Cape Town, University of Natal, University of the Western Cape and the University of Witwatersrand (ULSF, 2001). The Environmental Management for Sustainable Universities conference is a biennial event, and organized by lead organizations in Spain, the Netherlands, Peru, Argentina, Colombia, India and South Africa (www.emsu.org). The tendency for Universities world-wide are to strive towards "a healthy campus environment, with a prosperous economy through energy and resource conservation, waste reduction and efficient environmental management, and promotes equity and social justice in its affairs and export these values at community, national and global levels" (Alshuwaikhat and Abubakar 2008). NMMU should be no exception.

The NMMU are committed to holistic education (NMMU 2007) which is based on the idea that each individual finds identity, meaning, and purpose in life through connections to the community, the environment, and spiritual values (Miller 2009). It is therefore imperative that our curricula show students how their subjects relate to the environment with an environmental ethic integrated into each course. We have to lead by example by reducing wasteful and harmful actions and practices in our own systems and provide an ecologically, socially and economically healthy holistic learning environment for our students. "The goal is to develop a world population aware of and concerned about the environment and its associated problems and which has the knowledge, skills, attitudes, motivations and commitment to work individually and collectively towards solutions of current problems and the prevention of new ones" (UNESCO-UNEP 1976).

NMMU's sustainability values

NMMU aims to be a leader in South Africa's transition towards a more sustainable low-carbon economy and therefore its business processes, academic practices, operations and design of physical infrastructure should reflect its commitment to a sustainable future.

One of NMMU's values is "Respect for the Natural Environment", i.e.:

- We care about the environment and recognise our responsibility to conserve, protect and properly manage natural resources for ourselves and future generations
- We promote the integration of sustainability principles into our academic practices, institutional operations and design of physical infrastructure
- We encourage mutually beneficial and sustainable approaches to community service and engagement
- We inspire students and staff to embrace environmentally friendly practices.

Believing that a sustainable society must live in harmony with ecological processes, minimize consumption, and show respect for human dignity and health, NMMU is committed to continuous improvements in:

- *energy-efficient infrastructure* through technologies and practices that promote human health, save energy, minimize waste and pollution, and re-use materials to the greatest extent possible
- *environment-friendly maintenance practices* through energy-efficient, eco-friendly and cost effective operational practices, thereby minimizing our Carbon footprint, conserving water, eliminating chemical pollution and minimizing disturbance to natural ecosystems
- *incorporating sustainability in teaching and learning* by encouraging the inclusion of sustainability themes in teaching and learning materials and practices in all faculties
- *spearheading innovation and inquiry* in sustainable use and management of energy and water, waste management, the built environment and management of ecosystem services for human well-being
- *sustainable campus life* through awareness raising, inspiring staff and students, and leading by example by exposing our staff and students to information, equipment, infrastructure, policies and practices that promote sustainability
- *sustainability in our communities* through demonstration projects, action research and accessible information
- *setting targets, measuring and evaluating* our practices and their impacts on sustainability, and making appropriate adaptations where necessary.

Short term objectives

Objective1: Start now. Gain control over the university's energy usage by comprehensively and continuously auditing and reducing energy consumption and costs by at least 15% over the next 18 months and in so doing, establish accountability for energy management. Work closely with municipalities to develop strategies and procedures to save electricity;

Objective 2: Promote behavioural change. Promote a culture of energy awareness through continuously making Staff and Students conscious of energy efficiency and conservation opportunities. To initially focus on energy consumption and cost and urge the university community to switch off, inter alia, their computers, air-conditioning units and lights when they do not occupy space; and

Objective 3: Lead by example. Install energy saving technology and equipment and apply energy efficient construction techniques in accordance with good practice. Set up visible and operational pilot sites.

Objective 4. Promote and fund research into energy saving behaviours, practices and technologies and the impacts of energy consumption patterns on social, ecological and economic systems.

Objective 5: Promote organizational learning. Establish sustainability committees to develop, monitor and oversee green campus management plans. Participate in national and international programmes and processes that promote sustainable universities, and document the lessons learnt.

Recommendations

1. Start now

The immediate objective is to focus on effectively managing and controlling energy cost and given that electricity is the NMMU'S primary energy source, this will be the initial focus. The objective is to achieve a 15% saving within the first 18 months, which is considered to be a conservative estimate.

Recommendation 1.1
The following needs to be installed and stabilized on all campuses to help achieve this objective: Electricity meters on all the Campuses' substations; Municipal electricity accounts for all the Campuses; The Johnson Controls Building Management System's (JCBMS's) real time electricity consumption monitoring capability.

Recommendation 1.2
Using the JCBMS the following will be implemented: To monitor in real time, the electricity maximum demand and electricity consumption at all the Campuses and in all the buildings where JCBMS meters have been installed, and to install these meters where they are lacking; To build up an historical data base of electricity maximum demands and electricity consumption for comparison purposes in order to determine trends and savings. The data base information will also be used for corrective intervention purposes where there are unacceptable deviations.

Recommendation 1.3
For each Campus and building, to submit detailed monthly reports on: Demands and costs; Consumptions and costs; To reconcile JCBMS's data with the Municipal accounts' data; and To ensure the optimum functioning of the JCBMS, by, inter alia:-Regularly testing alarms, e.g. fire alarms, fridge alarms, and regularly testing and, if necessary, recalibrating sensors, e.g. temperature sensors, and regularly carrying out maintenance checks and minor repairs.

Recommendation 1.4
Detailed monthly reports of the above- mentioned items under points 3 and 5 would be submitted to an Energy Management Committee who will formulate and implement corrective actions. Annual energy audit reports need to be compiled for each Department and division.

Recommendation 1.5
To use the JCBMS for the manual and automatic switching off of large loads, e.g. ventilation and air-conditioning installations, on all campuses, which will ensure that:- loads are run only when required, and where possible, loads are shed to reduce the maximum electricity demand cost.

Recommendation 1.6
To complement the JCBMS on all campuses, the installation of ripple control switching relays on numerous geysers and small air-conditioning units is proposed.

Recommendation 1.7

To be able to setup and utilize the JCBMS optimally in real time requires a dedicated and knowledgeable company to manage this technology resource as an interim measure for 2009. It is proposed that R180 000 be allocated for this function for 2009 and that this amount be funded from the Municipal Services budget through savings achieved.

2. Promote behavioural change

According to the World Business Council for Sustainable Development (2008), professionals can be divided into four groups of green behaviour in terms of a) their know-how and b) their personal commitment. Those with a lot of knowledge can be either sceptics or leaders, depending on their personal commitment. Those with low knowledge can be either unengaged, or uninformed but enthusiastic. The strategies are either education (if knowledge is low) or convincing them (if personal commitment is low) (Figure 3).

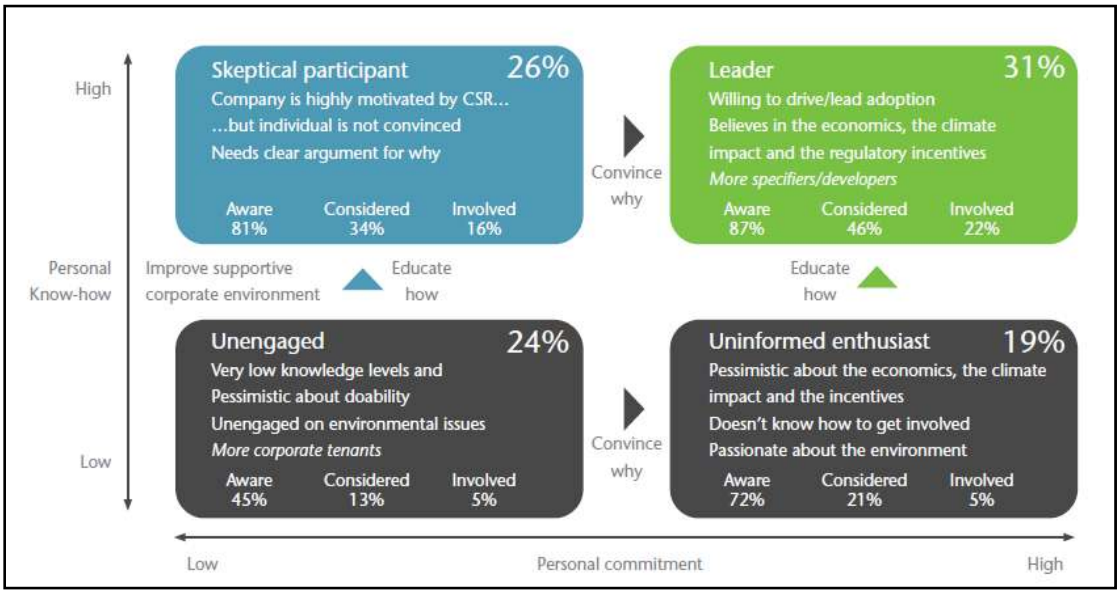

Figure 3. Four categories of environmentally sustainable behavior, depending on a) know-how and b) personal commitment (from WBCSD, 2008)

Educational strategies adopted by many universities are creating awareness of energy management through directed campaigns. RU in Grahamstown for example have posted tips on their website on how to use energy efficiently (RU 2009). One of the more creative campaigns is the Residence Energy Challenge implemented by UCT in association with Eskom. The challenge is a competition between the residences to see which can reduce their energy consumption the most (UCT 2009).

Recommendation 2.1

Engage Marketing and Corporate Relations in a campaign to raise awareness of a) the consequences of the status quo; b) the benefits of a low-energy economy and c) actions to promote energy savings and a low-Carbon economy

Recommendation 2.2
Encourage academics to incorporate material about energy, sustainability, carbon and climate change into undergraduate curricula

Recommendation 2.3
Participate in national and international green programmes such as the Environmental Management for Sustainable Universities movement, the Tailoires Declaration, and the MESA project

Recommendation 2.4
Build up a portfolio of the University's sustainability-enhancing activities and achievements, and use these to brand NMMU

Recommendation 2.5
Involve students at all levels in programmes and activities geared towards energy saving and mitigation of greenhouse gases on campuses and in communities. Implement a system of rewards or prizes for residences that have done the most to save energy

Recommendation 2.6
Invest in the professional development of select support staff in the use of cutting-edge technologies and strategies to save energy

3. Lead by example

On-site generation of electricity, while useful for demonstration or research purposes, is currently not financially viable. Photovoltaic cells and wind turbines are not financially viable, in terms of both electricity savings and emission reductions. Biogas generation, improvements in design and construction, and retrofitting buildings are far more efficient ways to save electricity and reduce Carbon emissions than on-site electricity generation (Osburn 2009a). Biogas digesters produce cheap methane from human, garden and kitchen waste. It is safe, odourless and can be used for heating, cooking, fuel for vehicles and electricity generation. This will only be financially viable once electricity prices have increased by about R 0.10 per kWh from 2009 tariffs (Osburn 2009a). Wind turbines are another option, bearing in mind that a small wind turbine will generate 2900 kWh, or just over R 1000 worth of electricity, per year

Almost 40% of household electricity is used to heat water. Solar water heating is therefore a technology which can be extensively used. It should form part of the design planning. At current prices, the payback period for a solar water heater is around five years, but this will decrease significantly when electricity tariffs increase.

Many universities are installing energy management systems (EMS) and upgrading energy and lighting in old infrastructure to more energy efficient systems. For example Binghamton University in New York have implemented an energy management system which has over 46 000 monitoring / control points which allowing for off site control of lighting and mechanical systems not in used (Binghamton university 2008). UCLA have also installed an EMS which includes motion sensing lighting in all common areas of the residences like the bathrooms and hallways (UCLA, 2008).

Binghamton University has upgraded all their equipment and lighting in old infrastructure for more energy efficient products including solar hot water systems (Binghamton University 2008). Rhodes University as well as the University of California, Los Angeles (UCLA) and University of Arizona are all in the process or have already upgraded all old buildings with energy efficient lighting and appliances (University of Arizona 2008, Rhodes university 2009 and UCLA 2008). The University of Arizona are currently installing solar panels in an effort to reduce their dependency on non renewable energy sources. Other efforts made by Arizona University include the installation of electricity usage meters on all equipment, "cool coats" applied to the roofs of buildings, more efficient electronic controls for water heating and cooling in residences and upgrading of the electrical fan systems used (University of Arizona, 2008). Harvard University have even installed wind turbines on their roofs in an effort to save electricity (Harvard University 2009). Some universities have implemented energy efficient policies for example UCLA have undertaken to use 20% green power by 2010 (UCLA, 2008). Other universities have undertaken to consider energy efficiency in all new infrastructure design in order to save as much energy as possible and Harvard University have bought into renewable energy credits (Harvard University 2009).

3.1 What is NMMU doing?

There are also examples in NMMU, e.g. the Centre for Energy Research is already generating half of the energy needs of the Outdoor Research Facility by PV, using a 1.6 kW array and will soon be adding a 2 kW wind turbine. This might appear small, but the initiative is experimental and is making an important statement. The Operations division have are committed to the Green Campus concept, and can list many examples of energy-saving air conditioning, lighting and building design on all campuses.

At the George Campus, a range of energy saving projects have been initiated, from insulation of ceilings in classrooms, use of natural ventilation systems for cooling, solar geysers in select residences, low-flow shower heads, energy saving lighting, optimizing the use of natural lighting where possible, and incorporating energy-saving technology in the design of all new buildings. The skills of support staff, under leadership of the Deputy Director: Operations, are being rapidly developed through attendance of conferences, discussion groups and training courses. Energy saving, water saving, health and saving are being integrated and is integrated into all mindsets at the George Campus. Proposals have been submitted to convert the entire George Campus into a Green Campus.

Recommendation 3.1

Exchange all worn conventional water heaters with solar heaters when the former are due for replacement. Solar water heaters used in conjunction with heat pumps are a very viable and cost-effective option

Recommendation 3.2

Develop proposals and raise funds for pilot projects in select faculties and campuses that are systematically monitored

Lighting

Lighting consumes 29-35% of office energy and it therefore makes sense to use energy-saving light sources. Neon tubes of high quality use 25% of the energy of conventional light bulbs and emit less heat, leading to savings in air conditioning costs. These tubes contain mercury and thus pollute the environment at source or when discarded. High quality fluorescent tubes contain phosphorous with a concomitant reduced mercury content requirement (Osburn 2009b). The collective replacement of light bulbs before they have reached burnout can result in significant savings in disposal costs and labour.

Light emitting diodes (LEDs) use very little electricity per (100 Lumens per kWh) and are useful for task lighting or display lighting, but are currently an expensive option. The use of task lighting instead of general lighting can result in significant energy savings due to only specific areas being illuminated.

Light switches should be provided at regular intervals to enable specific areas in open plan environments to be switched on. Light switches at individual work spaces enable individual workers or students to adjust their light requirements, and to make use of natural light where applicable.

Motion detecting switches can enable lights and air conditioners in specific areas to be switched off when not in use, leading to up to 80% savings in lighting. The payback time in public areas such as restrooms and parking garages can be as low as 2 years.

Maximizing daylight use

The correct placement of windows, light reflecting surfaces and light reflecting paint can reduce energy consumption by as much as 80%, if used together with dimmable lights and well spaced light switches. Walls and ceilings with reflective, light coloured surfaces also play a role in reducing the need for electric lighting. Light tubes are used to direct and reflect daylight to poorly illuminated areas and can save significant amounts of energy if used with dimmer switches. Skylights can bring additional light into single or double storey buildings.

Recommendation 3.2

Develop and implement guidelines for integrated light management plans for every building, to minimize energy use by maximizing the use of natural light, using appropriate light bulbs, spacing light switches and using dimmable and motion-detecting switches.

Energy-efficient infrastructure

Buildings and the construction activity associated with them account for at least 30% of world greenhouse gas emissions (Royal Institute of Chartered Surveyors, 2005). Buildings should be designed and where possible retrofitted to minimize energy use. This can be used by a combination of orientation, shading, and thermal enhancements to insolate the building against heat absorption in summer and heat radiation in winter. Roofs and ceilings need to be insulated with reflective foil and insulating fibre such as Isotherm or Aerolite. Natural ventilation to promote circulation and convection of air to cool buildings should be promoted through clever use of ventilation ducts. Architects affiliated with the Green Building Council should be consulted to design buildings with the specific objective of minimizing energy use. Existing buildings should, where possible, be retrofitted with energy-saving technologies.

Tygerberg administration building in Cape Town (comparable in size to Saasveld infrastructure) has implemented the above-mentioned policies as well as insulating kitchen urns and regulating air conditioners thermostats, have experienced a 22% saving of their annual electricity usage, (see Table 1) reducing the operational and environmental costs of the infrastructure.

Table 1. Tygerberg energy savings (Sustainable Energy Africa, 2007)

	Savings / month	Savings / year
kWh	12 000	144 000
Tons CO_2	13.2	158.4
Rands	3 240	38 880

In the US, rating systems that categorize buildings as either Platinum, Gold or Silver in terms of their 'green' status, have been used with great success and enthusiastically adopted by many universities, e.g. Harvard http://www.greencampus.harvard.edu. NMMU could be the first university in South Africa to adopt such a rating system.

Transport is also a major concern in terms of energy (fuels; oil) management; however, transport energy usage can be reduced through the promotion of shuttle service, car pooling, rideshare programmes, park and ride facilities and the encouragement of alternative modes of transport for example walking and cycling (Balsas, 2002; Tolley R, 1996). Stanford University promote carpooling and cycling and University of Washington in Seattle have arranged promotional offers for students at the local bike shops to encourage other cleaner form of transportation (Balsas, 2002). Furthermore, disincentives can help combat single person per vehicle transportation, which should transcend to all levels of the organisation (Balsas, 2002) and reliance on telecommunication options can further reduce the use of fuels (Balsas, 2002).

In light of all policies and strategies that have been mentioned above staff and Student awareness is vital for success. Campus staff should be setting examples for students by "practising what they preach". At Tygerberg the behavioural changes of the staff were monitored and their efforts were documented in the form of emails, display boards, pamphlets and newsletters (Sustainable Energy Africa, 2007).

Recommendation 3.3

Guidelines and a rating system for energy-efficient infrastructure should be developed an implemented via the Committee for the Designed Environment. This could be based on the LEED system used by US universities .

Recommendation 3.4

An energy conservation and emissions mitigation strategy for NMMU's transport systems, including official and student transport, should be developed and implemented.

Recommendation 3.5

Invest in the Johnsons Control system on all campuses

4. Take it to the next level through innovation, technology transfer and research

Universities need to be trend-setters in sustainable practices and should use their research and technology transfer capacity to achieve this. UCT established the Energy Research Centre (ERC) which focuses on the development of certain energy policies and research (UCT 2009) and Stellenbosch University established South Africa's National Energy Research Institute (SANERI) (Stellenbosch University, 2007).

The Centre for Energy Research at the NMMU must coordinate and thus optimize energy based research activities at the university and further advise the University through the Energy Management Committee on alternative energies and feasible opportunities. The research done by the Departments of Construction Management and Dept of Architecture into energy efficient building design and construction should be supported. The George Campus should be formally tasked to pilot selected renewable energy technology based projects and to provide recommendations on the use of different future energy sources and green design principles that seem most appropriate and feasible for the NMMU or specific sites of the university.

Recommendation 4.1

Invest in research and technology development into alternative energy sources and energy-efficient building design and construction, and apply this to pursue NMMU's sustainability principles and objectives.

Recommendation 4.2

Set up select academic units and the George Campus as a 'Green Campus' pilot site a to demonstrate the value of sustainable technologies and principles, and to monitor the economic, social and ecological impacts thereof

5. Promote organizational learning and governance for sustainability

Universities world-wide have established monitoring and evaluation systems, and governance structures, to promote sustainability and energy efficiency. Such structures function best if they 'cut across' academic and operational divisions, to spread responsibility and achieve buy-in. Performance objectives are also aligned with the sustainability objectives of organizations. At leading universities such as Harvard, Gothenburg and Stockholm an Office for Sustainability coordinates green initiatives and reports directly to the President or VC. At UCT the Green Campus Initiative is a volunteer organization with 500 members, whereas Rhodes University has an Environmental Committee as a sub-committee of Senate, and has appointed a dedicated environmental officer.

Many universities have set up monitoring systems to enable them to monitor, evaluate and learn about green practices, and use this in their branding, environmental reporting and assessing their Carbon footprint for certification purposes.

Recommendation 5.1
Develop an environmental policy, and proposals for environmental governance structure, via the Committee for the Designed Environment

Recommendation 5.2
Implement an energy monitoring system and regularly publish information on trends and achievements on the NMMU web site

Recommendation 5.3
Develop and implement a governance system for environmental policy making, monitoring, and oversight with broad representation

Recommendation 5.4
Consider the appointment of an NMMU environmental management officer, tasked with coordinating strategies to save energy and reduce environmental impacts, and a consultative energy engineer to assist with strategy and operational plan development

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