Renewable Energy & Energy Efficiency Institute

Namibia Energy Efficiency Programme (NEEP) in Buildings

FINAL REPORT

Baseline Study on Energy Efficiency in Buildings in Namibia

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Consulting Team:

emCON Consulting Group

P O Box 1900
Windhoek
Namibia
Tel +264 – 61 – 224 725
Fax +264 – 61 – 233 207

agama ENERGY

V/O CONSULTING

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Authors: Glenn Howard, Glynn Morris, Detlof von Oertzen

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1 EXECUTIVE SUMMARY

The Namibia Energy Efficiency Programme (NEEP) aims to promote the use of energy efficient technologies and practises in Namibia's commercial and residential building sector.

The aims of this study are to establish building energy benchmarks for buildings in Namibia and to identify and review energy efficiency standards with a view to making recommendations on appropriate energy efficiency approaches appropriate for Namibia.

1.1 Building energy and demand benchmarking

This study includes a sample of 52 buildings from four localities (Windhoek, Keetmanshoop, Oshakati/Ongwediva, Walvis Bay/Swakopmund) based on building occupancy as defined by the building regulations (SANS 10400) for the follow occupancies:

- F1 Large Shops (including shopping malls)
- G1 Offices
- H1 Hotels

Electricity billing records, floor area, occupancy and other data were surveyed for each building and interviews were conducted with building owners or their representatives. Other energy sources (e.g. LP gas, diesel, paraffin) were included in the energy consumption where applicable.

The zoning of erven for a number of towns in Namibia was compared to each other and to the occupancy classifications in the building regulations. It was found that there is little correlation between urban land zoning and building classification types, also all towns have different zonings with little correlation between towns which complicates data analysis. Local authority land databases generally do not include floor area of improvements, which makes it impossible to determine the distribution of building types and sizes in Namibia using town zoning databases.

A sample of Namibian urban zoning data illustrates that residential buildings are important as they represent 91% of improved urban erven or 64% of developed urban land, while 6% of erven (15% of land area) can be classed as government, industrial, business and office.

Results for the large shops' occupancy were sub-divided into supermarket and warehouse shops as these were found to have widely different energy requirements. Office buildings are reported separately as public and private office buildings.

Energy benchmark values are measured as total annual energy consumption divided by the net square meter area of a building (units kWh/m²/annum), as defined by various standards, including SANS 204 (Energy Efficiency in Buildings). SANS 204 stipulates maximum energy and electrical demand values for different building occupancies per various climatic zones. The SANS 204 climatic zones exclude Namibia and thus assumptions regarding the climatic zones of the four localities sampled in Namibia were made. The electrical demand benchmark is measured in units of VA/m².

Figure 3 presents the average energy benchmarking results for the various occupancies. Clearly supermarkets are high energy consumers. The study was unable to identify any obvious climatic influence on the energy benchmarks. It appears that energy intensity is more related to activity and facilities or services provided, with facilities in Windhoek in general being more energy intensive than other localities.

Figure 3: Summary of average energy consumption in kWh/m²/annum per locality

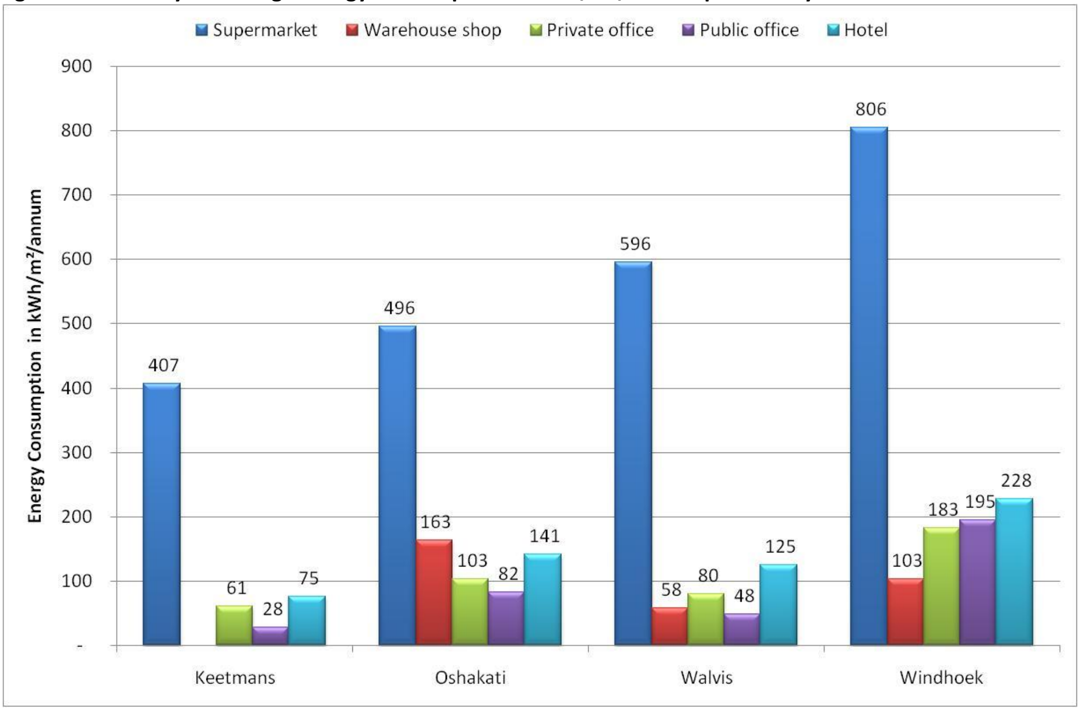


Figure 7: Comparison of energy benchmark results with SANS 204

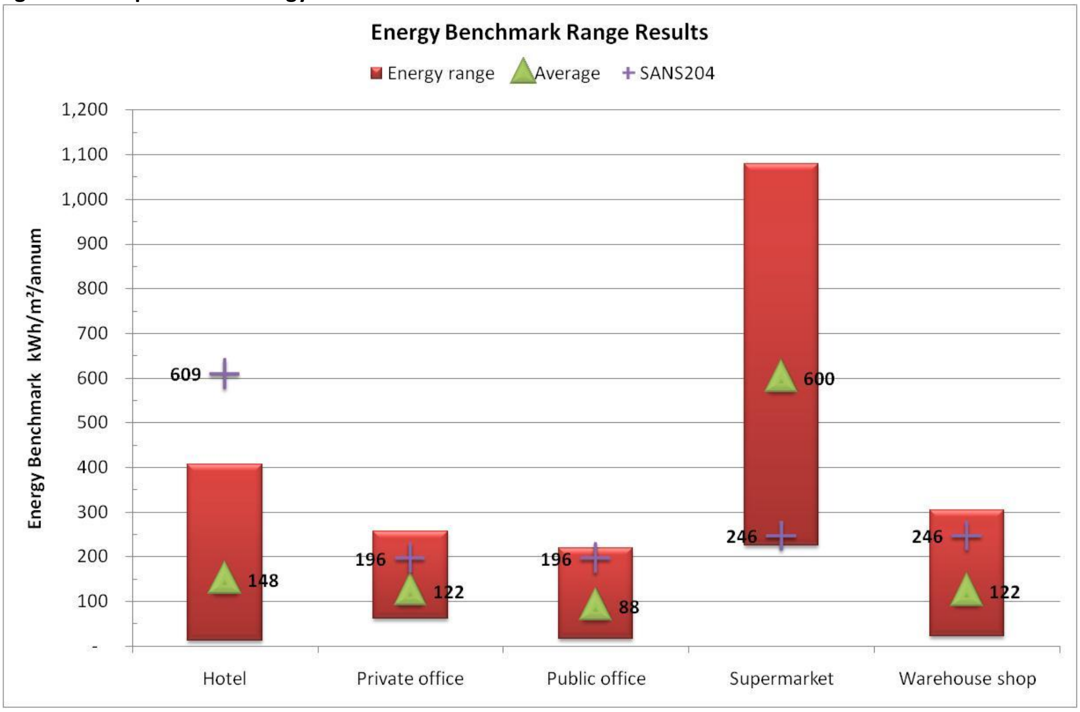


Figure 7 shows the range of energy benchmark values obtained together with the average values, compared with the SANS 204 average values for the four localities. In most cases the SANS 204 maximum values do not present a challenge for compliance by most building occupancies, with the exception of supermarkets which are a special high energy class of *large shops*. SANS 204 assumes that buildings comply with regulations and standards in terms of artificial illumination, comfort conditions and typical occupancy levels. Many of the survey buildings differ in terms of illumination levels, comfort and occupancy. Compliance with standards is not commonly monitored in Namibia.

Figure 8 provides the average electrical demand benchmark results for different building occupancies in the four localities. Some gaps exist in the data as not all facilities surveyed had demand data available, and care must be exercised as some samples represent a single data item. Again, no conclusions can be drawn based on climatic factors.

Figure 8: Summary of average electrical demand benchmark, in VA/m²

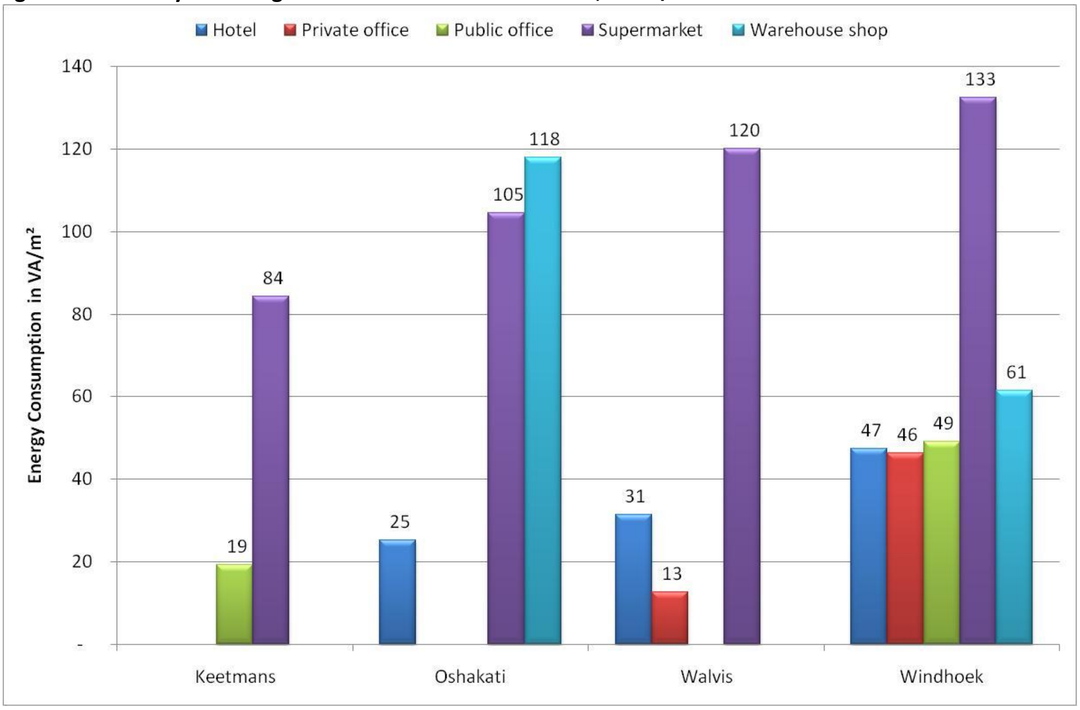


Figure 12: Comparison of electrical demand benchmark results with SANS 204

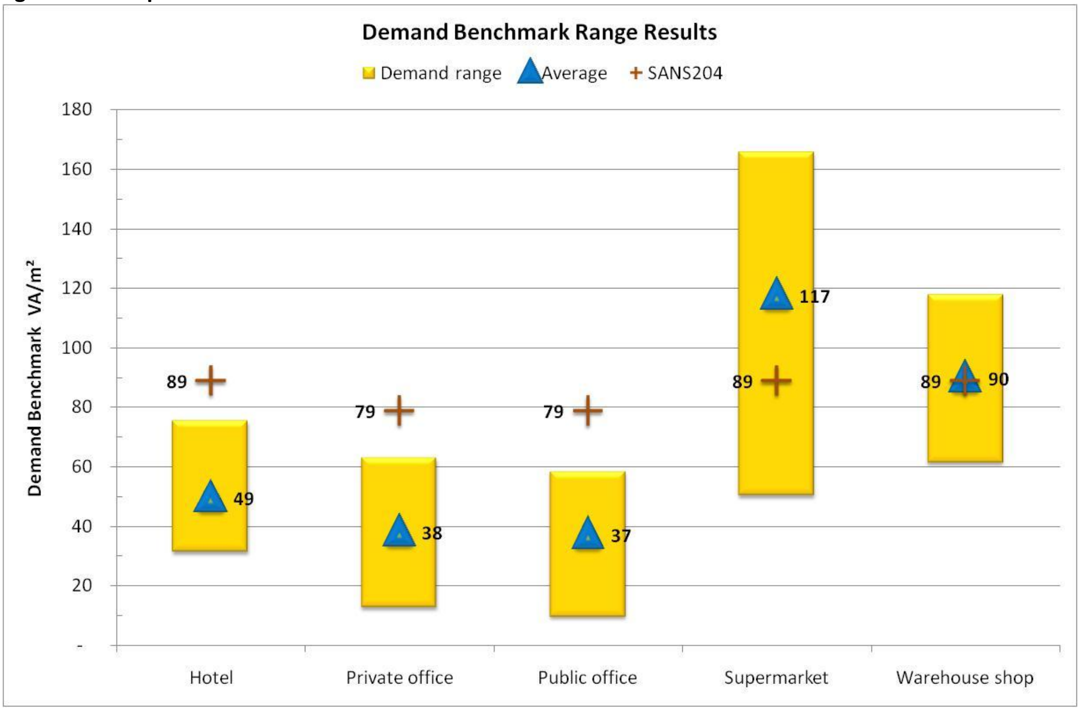


Figure 12 shows the range of demand results and their averages, compared to the SANS 204 maximum values. The warehouse shops sub-set of the large shops' occupancy compares well with SANS 204 values, while supermarkets are higher. Offices and hotels sampled fall well below the SANS 204 maximum values.

Hotel industry benchmarks of kWh/bednight/annum and VA/bednight were also evaluated and compared in the study. These results are of specific interest to the hospitality industry, but not of particular use to the electricity supply industry.

Anecdotal results for comparable buildings indicate that significant energy savings are possible:

- Comparable hotels use 35% less energy than the maximum.
- Comparable supermarkets use 40% less energy than the highest recorded value.
- Comparable office buildings use almost 60% less energy than the worst case.

The report discusses the potential for energy efficiency opportunities in the light of some of the survey findings; including measures such as the utilisation of alternative energy sources, building envelope and orientation, heating, ventilation and air conditioning, lighting, hot water, elevators and escalators, renewable energy sources, appliances and power factor correction. It is concluded that substantial scope for improvements exist.

The market perception of respondents was assessed following interviews with representatives for all of the buildings. The following emerged from this process:

- Only about a third of respondents understand their electricity tariffs.
- Only about a quarter of respondents have heard of energy audits, and only one facility had undergone an energy audit.
- While energy efficiency measures are scarce, it appears that energy efficient CFL advocacy has had an effect.
- Respondents are eager to address energy efficiency, but express a wish for clear readily-available information.
- Building operators are optimistic, with 77% believing that their facilities energy consumption is normal to highly efficient.

A priority list of 20 buildings which are clear candidates for an energy audit is presented, sorted according to their total annual energy consumption (±32 GWh/annum).

While this study excludes benchmarking of domestic energy consumption, the importance of this sector is highlighted by the fact that around 40% of urban energy consumption is domestic. Domestic consumption is made all the more important by the fact that international experience of emerging economies, such as Namibia, predict a surge in domestic energy consumption as "suppressed demand" will follow as a result of accelerated housing delivery, poverty alleviation and increased penetration of appliances. International experience has shown that the most effective approaches to energy efficiency in the domestic sector include

- Energy efficiency awareness and behaviour change programmes.
- Improved design and construction of new housing including planning procedures and regulatory measures.
- Energy labelling programmes for appliance efficiency.
- Energy efficiency and demand side management programmes.

1.2 Energy efficiency standards

The energy efficiency of buildings can be considered in terms of the typical lifecycle of buildings, where specific and appropriate “trigger points” can be used to effect energy efficiency conversions. Typical ‘trigger points’ include:

- the sale of a property
- a change in the leasehold on a property
- the replacement of equipment and components installed on the premises, and
- refinancing, remodelling, renovation or rehabilitation events.

The opportunity for applying energy efficiency standards for buildings is primarily in the concept development, design and planning approval phases (and subsequently in the refurbishment phases) of the overall building lifecycle. The opportunities for energy efficiency in the operational phases of the lifecycle of a building are primarily of the demand-side management (DSM) type, while energy efficiency improvements should form part of upgrade and renovation programmes.

The demand-side management (DSM) study (completed in 2006) has been the most significant recent initiative in Namibia to recommend the establishment of energy efficiency interventions which are applicable to buildings. The DSM study made specific recommendations, but the impact that the DSM initiatives had on the energy use in buildings cannot be quantified, as pre-implementation baseline consumption data is unavailable.

International standards, developed over the last 40 years, were initially based on prescriptive requirements, specifying materials and systems. Increasingly however, the trend is towards performance based standards, which allow innovation despite being a little more complex to implement.

A number of internationally recognised energy efficiency tools and rating systems have been developed, including:

- BRE Environmental Assessment Method (BREEAM) [UK]
- Leadership in Energy and Environmental Design (LEED) [USA]
- Green Star [Australia]
- SANS 204 national standard for energy efficiency in buildings [South Africa & Namibia]

Based on the review of the international experience, the two most likely energy efficiency standards frameworks for consideration in Namibia are

i. Obligatory: the SANS 204 / SANS 10400 national standard for energy efficiency in buildings and code of practice for building regulations in South Africa, and
ii. Voluntary: the GreenStar system for rating Green Buildings which is implemented in South Africa.

Currently, the SANS 204 standard is under review. SANS 204 is a performance-based standard, which sets out energy demand and consumption for different categories of building occupancy and for different climatic zones. SANS 204 has not yet been applied in Namibia as an obligatory standard, which makes SANS 204 a voluntary energy efficiency framework rather than a legal requirement. The applicability of this standard to Namibia is considered to be appropriate with the following practical considerations:

- Technical: The climatic zones defined in SANS 204 exclude Namibia at this stage.
- Legal: SANS 204 can be enforced in Namibia as SANS standards are legally enforceable.
- Institutional: The local authority responsible for planning approval of new buildings should also be made responsible for approving the energy efficiency compliance of new buildings. SANS 204 makes provision for municipalities to accept Energy Efficiency Certificates (or label such as an Energy Efficiency Passport) as issued by a 'competent person' as evidence of compliance with the standard.

The GreenStar SA rating system is currently licensed for use in South Africa, and is administered as a voluntary programme by the Green Building Council of South Africa (GBCSA). Application in Namibia would require it to be licensed for use in Namibia as well. It is speculated that Namibia might not currently enjoy sufficient market activity to support its own comprehensive Green Building rating system.

The report outlines other international energy efficiency experiences and lessons learned from them, including:

- Eskom's Demand-Side Management Programme
- Bangalore City Environmental Building Regulations and Guidelines
- California Energy Commission (CEC) Energy efficiency in existing buildings
- National Renewable Energy Laboratory (NREL) procedure for measuring and reporting energy performance

Conclusions are drawn from the study, and specific recommendations are made for the way forward. Readers interested in the detailed findings of the study are referred to the specific sections of the report.

2 INTRODUCTION

2.1 Background

Namibia currently imports more than 50% of its electricity requirements. Regional generation capacity is stretched to its limit. This poses a significant threat of future supply interruptions, which in turn adversely impact Namibia's economic growth. The Namibian government is therefore exploring new electricity generation opportunities, and seeks to promote energy efficiency and demand side management to further mitigate this risk.

The Namibia Energy Efficiency Programme (NEEP) aims to promote the use of energy efficient technologies and practises in Namibia's commercial and residential building sector.

The NEEP project has characterised the Namibian building sector as follows:

- National building codes do not incorporate standards and recommendations on energy efficiency (EE) and renewable energy (RE) for
    - building envelope (insulation, ceiling materials, etc.)
    - lighting (technologies, control systems, etc.)
    - heating, ventilation and air conditioning (HVAC) systems
    - water heating systems (e.g. solar water heating), and
    - indoor air quality.
- Potential energy-efficient technologies for buildings are not adequately identified in the market.
- Inadequate recommendations have been made on energy-efficient equipment and materials that have been internationally recognized and tested.
- Building owners having no access to financial resources to introduce energy-efficient technologies in their buildings, mainly because financial institutions are not familiar with such technologies and practices, and often present a reluctance to extend credits for such undertakings.
- Building owners have insufficient access to technical resources to conduct energy audits in their buildings and evaluate the potential cost-savings and measures that could bring about long-term energy savings.
- Few energy auditors in Namibia are sufficiently qualified to undertake such audits in buildings.
- Few energy audits have been conducted in the Namibian building sector.
- Principal players including manufacturers, retailers, designers, architects, constructors and others are not promoting EE. According to a recent study, i.e. EE Baseline Survey undertaken under the Renewable Energy and Energy Efficiency Capacity Building Programme (REEECAP), 17% of local architects surveyed were not aware of EE issues in buildings whilst 67% were aware but still are not implementing EE measures in their practice.

2.2 Study objectives

The main objectives of the present study are twofold:

1) Identify the existing energy consumption benchmarks for buildings in Namibia, in order to establish a picture of the “before” NEEP scenario.
2) Identify and review energy efficiency standards and regional and international energy efficiency approaches and implementations, in order to make recommendations for the possible implementation of energy efficiency programmes suitable for the specific conditions in Namibia.

2.3 Structure of the report

This report is structured to follow the two main objectives, i.e.

- Section 3 describes the approach and methodology used in the study
- Section 4 describes the findings of the study
- Section 5 discusses the issues related to domestic benchmarking
- Section 6 presents the findings on the review of energy efficiency standards and regional and international energy efficiency approaches and implementations
- Section 7 presents the study’s conclusions, and
- Section 8 presents the recommendations emanating from this study.

Additional detail is attached to the report in numbered Appendices.

3 Approach and Methodology

3.1 Selecting the building sample set

Building types are classified by the Building Regulations applicable in Namibia, i.e. SANS 10400. The standard for energy efficiency in buildings, SANS 204[1] uses a reduced list of the same building classifications.

A detailed rationale for the inclusion and exclusion of certain building classifications in this study is provided in Appendix 1. The building types selected for the benchmarking exercise are:

- F1 Large Shops (including shopping malls)
- G1 Offices
- H1 Hotels

Classification “F1 Large Shops“ (with a floor area above 500 m²) includes shopping centres, which cover a variety of commercial activities, from simple warehouse type shops to large-scale supermarkets. The sample buildings selected, however, include mainly supermarkets in order to provide a comparative sample, while a few “warehouse-like” shops are also included to allow a comparison of the range of energy consumption in this class of buildings.

Office buildings commonly also include commercial shops which are provided for from the same electrical meter. Here, the building selection targeted pure office buildings wherever possible. The office buildings selected include both public and private buildings.

Hotels were selected to provide a range of hotel sizes and types, from larger through to smaller bed and breakfast accommodation establishments.

Residential buildings were excluded, as the scope and extent of work for a representative sample of domestic energy consumption would have exceeded the scope of the present project.

Buildings of the three classifications were chosen from four localities in Namibia in order to include different climatic regions. These localities are listed in Table 1. Note that the climatic zones allocations are indicative, as SANS 204 does not specify climatic zones for Namibia.

Table 1: Building survey localities and their assumed SANS 204 climatic zones

Locality	Region [2]	Climatic Zone Description	Zone Number per SANS 204
Windhoek	Khomas	Cold Interior	1
Keetmanshoop	Karas	Temperate Interior	2
Oshakati, Ongwediva	Oshana	Hot Interior	3
Walvis Bay, Swakopmund	Erongo	Temperate Coastal	4

[1] SANS 204 is described in more detail in Section 6.4, SANS 204 – Energy efficiency in buildings

[2] SANS 204 does not describe in detail how the various climate zones were established. The categorisation of the climatic zones as used in this study is therefore based on the authors' interpretation of the climatic zones as introduced in the SANS 204.

The project proposal undertook to sample 38 buildings of the three classifications (F1, G1, H1). A selection of 72 buildings from the localities listed in Table 1 was made, and building owners/tenants were invited to participate, of whom 56 agreed. Finally, after attrition for reasons such as a non-provision of information, unsuitable metering arrangements, withdrawal by participants, 52 buildings were included in the final sample set, as shown in Table 2.

Table 2: Final building sample composition

Building Classification	Keetmans	Oshakati	Walvis	Windhoek	Grand Total
F1: Large Shop	2	6	5	5	18
G1: Offices	4	5	5	6	20
H1: Hotel	3	4	3	4	14
Grand Total	**9**	**15**	**13**	**15**	**52**

3.2 Survey methodology

Following agreement by participants, each building owner/occupier/tenant representative was requested to provide the following information:

- 24 months of electricity billing accounts.
- Other fuel accounts (LP gas, diesel, paraffin, wood) covering 24 months.
- A set of building layout plans, for the determination of the building floor area.
- Occupancy figures:
  - Hotels – monthly bed-night figures
  - Offices – approximate number of persons working in the building.

In some cases electricity accounts were obtained directly from the supply authority. Building plans were also drawn from local authorities and from the Department of Works archives in the case of public buildings.

The following procedure was followed for each building:

1) A walk-through evaluation of the building was conducted to obtain a cursory assessment of building construction and technologies. Building data collected are included in Appendix 3.
2) An interview was conducted with an appropriate person who represented either the tenant or building owner (as applicable). Normally this was the manager. In the case of public buildings a local Department of Works Maintenance Division representative was interviewed. The interview questions are listed in Appendix 2.

3.3 Data collection and analysis

In addition to the data collected from buildings and their operators, data was also obtained and analysed for:

- Electricity sales information from various supply authorities.
- Erf information in a variety of urban settlements (Town Councils and Municipalities).

Many buildings comprise a mixed occupancy. For example, a building might contain offices, commercial shops and residential components, supplied from a single meter, with no sub-metering. The buildings sampled were selected to ensure that the building sample excluded mixed occupancy classes as far as possible, and care was taken that the floor area evaluated corresponded exactly with the electrical metering.

Some of the information obtained from sites is of a qualitative rather than a quantitative nature. This was necessary due to project constraints, as detailed quantitative data collection falls in the scope of a full energy audit. This implies the following simplifications:

- The average distribution of lamp types within a building were estimated, rather than quantified.
- Only a few illumination levels were sampled and then averaged.
- Only a qualitative assessment was done of day-lighting levels.

The energy and demand figures for all buildings were analysed. The following comments apply to billing information:

- While 24 months of data capturing was attempted, some buildings are new and thus only 8 – 12 months of billing data was available.
- Energy consumption (kWh) figures are adjusted to a daily consumption average according to actual meter reading dates, and then corrected for a 28/30/31-day month as applicable. This is done to smooth the monthly consumption in order to identify seasonal variations and highlight any billing discrepancies. Some electricity accounts do not state the meter reading date, making such adjustments impossible and resulting in fluctuating monthly values if meters are read irregularly.
- In some cases supply authorities charge for an estimated amount in a month. Where these are identified, values have been averaged by applying actual values over the months which were affected.
- In some cases, supply authorities charge a constant maximum demand, either according to an initial customer stated demand or some previous maximum demand reading. Actual kVA demand readings were requested from supply authorities but this information was not always available. Constant kVA charge data is ignored as this does not represent a measured value.
- Many of the buildings are not subject to a maximum demand tariff, and consequently, combined with the point above, demand data constitutes a smaller sample compared with energy consumption data.
- Time of use billing was implemented by many electricity supply authorities during the previous 24 months. This information was recorded, but is not included in this report as it is not relevant for the building's energy benchmark.

Other fuel sources (LP Gas, Diesel, Paraffin, and Wood) displace electrical energy when used for tasks such as heating, cooking, baking and water heating. SANS 204 stipulates that non-electrical consumption, such as from fossil fuels, shall be accounted for on a thermal equivalence basis, i.e. by converting mega joules to kilowatt hours. Thus participants were requested to provide billing records for their consumption of other fuel sources used. In some cases, participants were only able to provide average monthly consumption and not actual billing records. Where bills were provided, the consumption was taken to occur in the month stated on the invoice. The conversion rates used for the various fuels are [3]:

- LP Gas : 51 MJ/kg
- Diesel : 38.6 MJ/litre
- Paraffin : 37.3 MJ/litre

[3] See for example http://en.wikipedia.org/wiki/Heat_of_combustion

Despite assurances that occupancy figures for Hotels will not be published, Hotel owners and operators were still concerned and reluctant to provide such figures. Some Hotels were "lost" to the project for this reason.

The Government is the largest property owner in Namibia. The Department of Works in the Ministry of Works and Transport is the Government custodian of buildings and responsible for maintaining an asset register and undertaking maintenance. The individual Ministries are responsible for the budgeting and payment of energy accounts. In the case of public buildings, the identification of an appropriate person to interview proved to be challenging. Neither the Department of Works nor the occupying Ministry presently has any staff specifically responsible for energy consumption and/or ensuring that energy efficiency measures are implemented in public buildings.

The integrity of the data provided is assumed to be correct. Barring any obvious variations, which were investigated and resolved, the data obtained is taken at face value. This refers in particular to:

- Building plans reflect actual floor area of the existing building.
- Alternative fuel consumption figures and data provided are correct and complete.
- Metering and billing information is accurate.
- Occupancy figures provided are accurate.
- Answers to questions put to respondents are correct.

4 Findings

4.1 Characterisation of building categories

4.1.1 Classification of buildings

Building types are classified by Building Regulations, SANS 10400[4], while the applicable standard for energy efficiency in buildings, SANS 204, uses a shortened list of the same building classifications. The SANS 10400 list is reproduced in Appendix 1.

Town Planners for each Municipality or Town Council allocate the erven in a Town Planning Scheme with zoning descriptions which restrict the end use of each portion of land.

Unfortunately the SANS 10400 building regulations and town planning classifications differ substantially, which might be a necessary consequence as they fulfil different functions. In addition, no two local authorities use exactly the same erf zoning list. The urban town planning zoning definitions for the towns sampled are listed in Table 3. The following observations are made:

- Not all local authorities have an “Office” zoning. In many cases “Office” classification falls under “Business” zoning.
- While some local authorities include “Accommodation” and “Hospitality” there is no zoning which compares to “Hotel” classification.
- The “Large Shops” classification is also generally included among “Business” zoning.

Distinct differences exist between municipal zoning and building regulation classification of buildings, which complicates co-ordination or sharing of data.

[4] According to the Namibian Standards Institution (NSI), by agreement, South African standards of the South African Bureau of Standards (SABS) automatically apply in Namibia. SANS refers to “South African National Standard”.

Table 3: Town planning zoning definitions for various urban centres in Namibia

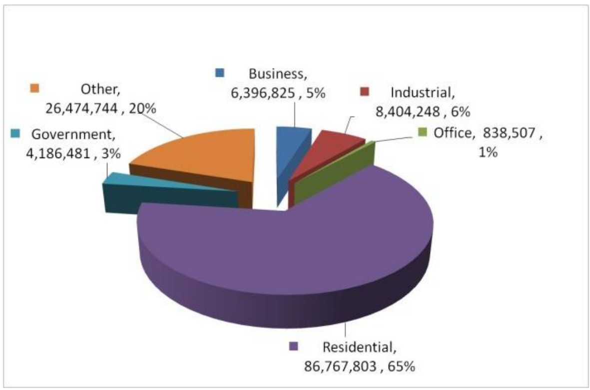
Type Group	Windhoek	Walvis Bay	Swakopmund	Oshakati	Ongwediva	Ondangwa	Rundu	Katima Mulilo	Keetmanshoop
Business	Business	Business 1	General Business	Business	Business	Business	Business	General Business	Business 1
	Restricted Business	Local Business	Local Business	Local Business	Local Business		Local Business	Local Business	Business 2
			Parastatal					Parastatal	Parastatals
Residential	General Residential	General Residential 1	General Residential 1	General Residential	General Residential	General Residential	General Residential	General Residential	Residential 1
	Residential	General Residential 2	General Residential 2	Accommodation	Residential	Accommodation	Residential	Residential	Residential 2
		Single Residential		Intermediate Residential				Informal Residential	Residential 3
			Single Residential	Single Residential		Single Residential	Informal Residential		
				Informal Residential		Informal Residential	Hospitality	Hospitality	
Government	Government	Government Purposes	Authority	Authority				Government	Government
					Civic	Civic	Civic Authority		
	Municipal	Municipal Purposes	Local Authority				Local Authority	Local Authority	Local Authority
Industrial	Industrial	Industrial	General Industrial	Industrial	Industrial	Industrial	Industrial	Industrial	Industrial 1
	Transport & Communication	Light Industrial	Light Industrial	Light Industrial	Light Industry	Light Industrial	Light Industrial		Industrial 2
Office	Office			Office	Office	Office	Office	Office	
Other	Private Open Space	Private Open Space	Private Open Space	Private Open Space	Private Open Space	Private Open Space	Private Open Space	Private Open Space	Private Open Space
	Public Open Space	Public Open Space	Public Open Space	Public Open Space	Public Open Space	Public Open Space	Public Open Space	Public Open Space	Public Open Space
			Beach Area				Infrastructure Reserve		
	Cemetery	Cemetery	Cemetery				Local Authority Reserve		Cemetery
	Special	Special	Special	Special	Special		Special	Special	Special
	Street	Street	Street			Street	Street	Street	
	Institutional	Institutional	Institutional	Institutional	Institutional	Institutional	Institutional	Institutional	Institutional
	Undetermined	Undetermined	Undetermined	Undetermined	Undetermined		Undetermined	Undertermined	Undetermined
	Unknown zoning	Unknown zoning	Unknown zoning				Unknown zoning	Proposed Erven	Unknown zoning
		Railway & Harbour		Service Station	Service Station	Service Station	Service Station		
			Parking	Parking		Parking	Parking	Parking	
		Combined Land Use					Sports Fields		
		Special Designated Area					Civic Reserve		
							Reservation: Government Education		
							Reservation: Government General Administration		
							Reservation: Local Authority General Administration		
		Conservation Area	Powerline Servitude	Conservation			Agriculture	Nature Reserve	Education

4.1.2 Building types and sizes

The urban areas zone names have been grouped into similar classifications, as indicated in the left hand column of Table 3, to provide a reasonable comparison.

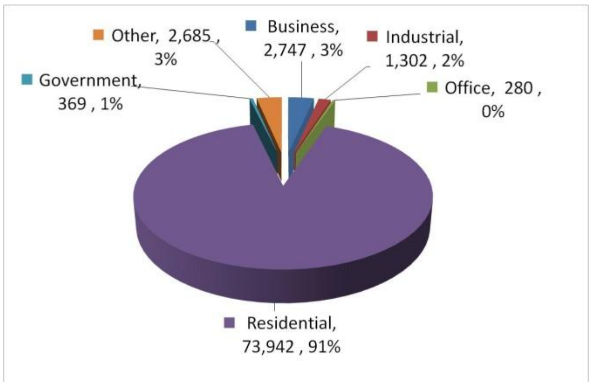
Enumeration of local authorities' databases, including only improved erven[5], provides an indication of the distribution of the number of erven and their total land area. These are shown in Table 4 and Table 5, and illustrated graphically in Figure 1 and Figure 2 below.

Figure 1: Area (m²) of improved erven



Developed residential land comprises 65% of improved urban land area, and 91% of the number of improved erven. Commercial zoned land (Business, Industrial and Office) comprises around 12% of urban development by land area, and 5% of the total number of improved erven. Government (central, regional and local) has developed 3% of urban areas, which comprises 1% of the total developed erven.

Figure 2: Number of improved erven



While the urban zoning information shows that residential land comprises the majority of urban land allocation, 15% of improved land area and 6% of the improved erven stock are owned and used by the private and public sector.

While some urban zoning databases list improvement value, such values are qualitative and extrapolation to improvement area is not possible. No local authority databases presently include the approved improvement floor area. Bulk factors[6] for developed erven vary by local authority, zoning and suburb, and thus bulk factors cannot be used to extrapolate to floor area either. The Deeds Office register is not digital (yet), neither does it record improvement area (it is mainly concerned with land ownership) other than for sectional title development. There is thus no simple means to determine the total m² area of improvements on urban erven.

Building data in Namibia is thus not suitable for allowing simple enumeration of the total building stock by classification and size.

[5] *Improved* erven are erven which are developed and have a building on them.

[6] *Bulk factor* is *also referred to as the 'floor area ratio' (FAR) and indicates the total floor space that may be built on in a property. The FAR is obtained by dividing the gross floor area of the building by the area of the property.*

Table 4: Urban zoning groups by number of improved erven

Zoning Group	Windhoek	Walvis Bay	Swakopmund	Oshakati	Ongwediva	Ondangwa	Rundu	Katima Mulilo	Keetmanshoop	Total erven	Percent
Business	982	342	249	127	7	106	512	227	195	2,747	3%
Industrial	469	364	133	27	124	79	43	25	38	1,302	2%
Office	242	-	-	25	-	5	4	4	-	280	0.3%
Residential	36,319	8,031	5,910	3,850	1,962	1,476	8,599	4,611	3,184	73,942	91%
Government	102	74	56	20	8	33	10	20	46	369	0.5%
Other	441	446	1,080	38	107	52	302	82	137	2,685	3%
Totals	**38,555**	**9,257**	**7,428**	**4,087**	**2,208**	**1,751**	**9,470**	**4,969**	**3,600**	**81,325**	**100%**

Table 5: Urban zoning groups by area of improved erven in m²

Zoning Group	Windhoek	Walvis Bay	Swakopmund	Oshakati	Ongwediva	Ondangwa	Rundu	Katima Mulilo	Keetmanshoop	Total m²	Percent
Business	2,761,839	481,782	485,547	668,309	8,567	307,595	700,823	350,583	631,781	6,396,825	5%
Industrial	3,207,545	2,193,399	550,372	428,458	375,600	331,125	396,294	514,033	407,422	8,404,248	6%
Office	471,352	-	-	285,377	-	33,763	24,981	23,034	-	838,507	0.6%
Residential	57,851,687	4,769,812	4,078,465	5,097,062	1,217,988	2,302,137	5,774,368	3,191,616	2,484,668	86,767,803	65%
Government	1,676,286	244,418	229,447	503,453	53,170	515,788	213,441	612,363	138,115	4,186,481	3.1%
Other	11,309,595	3,031,758	2,621,583	1,328,009	357,406	1,386,135	1,739,635	2,298,087	2,402,536	26,474,744	20%
Totals	**77,278,304**	**10,721,169**	**7,965,414**	**8,310,668**	**2,012,731**	**4,876,543**	**8,849,542**	**6,989,714**	**6,064,522**	**133,068,607**	**100%**

4.1.3 Building sample sizes

Table 6 lists the total net floor area and average floor area of the building sample considered in this project.

Table 6: Building sample total and average net area

Locality	Sum of Building Net floor area (m²)						Average of Building Net floor area (m²)		
	F1: Large Shop		G1: Offices		H1: Hotel		F1: Large Shop	G1: Offices	H1: Hotel
Keetmans	2,155	6%	9,065	9%	6,389	13%	1,078	2,266	2,130
Oshakati	11,351	33%	4,530	5%	6,420	13%	1,892	906	1,605
Walvis	8,610	25%	11,234	12%	5,946	12%	1,722	2,247	1,982
Windhoek	12,359	36%	70,744	74%	29,948	61%	2,472	11,791	7,487
Grand Total	**34,475**	100%	**95,573**	100%	**48,703**	100%	**1,915**	**4,779**	**3,479**

Not surprisingly, the shops, offices and hotels in the economic hub of Windhoek are larger than those in the other centres.

4.2 Determination of energy consumption

4.2.1 Energy benchmark

Energy consumption from billing records has been analysed in accordance with SANS 204, which evaluates energy consumption per m² of net building area[7] per annum. Energy consumption is measured in units of kWh/m²/annum. A summary of the average energy consumption for all building types per locality is presented in Table 7.

The average value for each building type is indicated and shows that Supermarkets are by far the most intensive energy consumers. The *Large Shops* classification has been sub-divided into *Supermarket* and *Warehouse shops*, as these exhibit different energy benchmark levels.

The *Offices* classification has also been split into *Private* and *Public.* It appears that public offices, on average, have a smaller energy demand than private offices. Certainly for Windhoek the difference between public and private offices is not as pronounced as in other centres. The *Hotel* average benchmark is slightly higher than offices and warehouse shops.

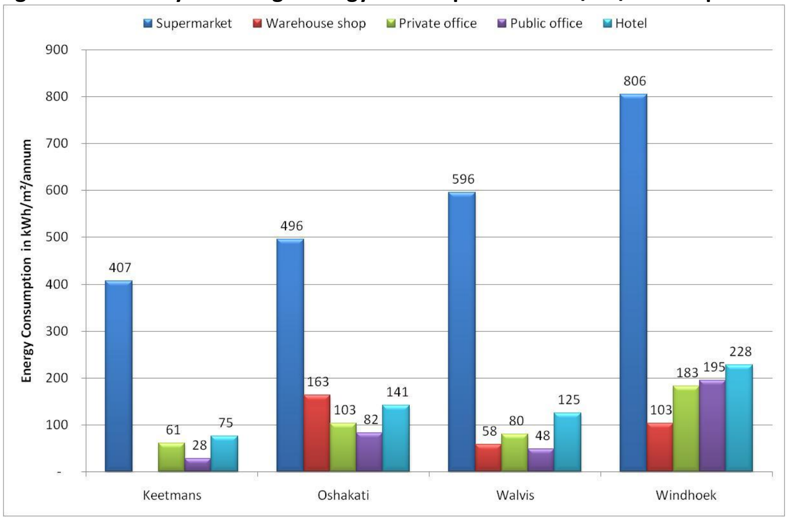
Figure 3 shows the results graphically.

Table 7: Summary of average energy consumption in kWh/m²/annum

Locality	Supermarket	Warehouse shop	Private office	Public office	Hotel
⊞ Keetmans	407		61	28	75
⊞ Oshakati	496	163	103	82	141
⊞ Walvis	596	58	80	48	125
⊞ Windhoek	806	103	183	195	228
Average	600	122	122	88	148

[7] SANS 204 defines ***net floor area*** as the sum of all areas between the vertical building components (walls, partitions), excluding parking garages and storerooms.

Figure 3: Summary of average energy consumption in kWh/m²/annum per locality



4.2.1.1 Large Shops (F1) energy consumption

The average energy consumption for large shops is summarised in Table 8 and Figure 4. Clearly, Supermarkets are far more energy intensive than Warehouse Shops. Supermarkets generally include most of the following energy intensive facilities:

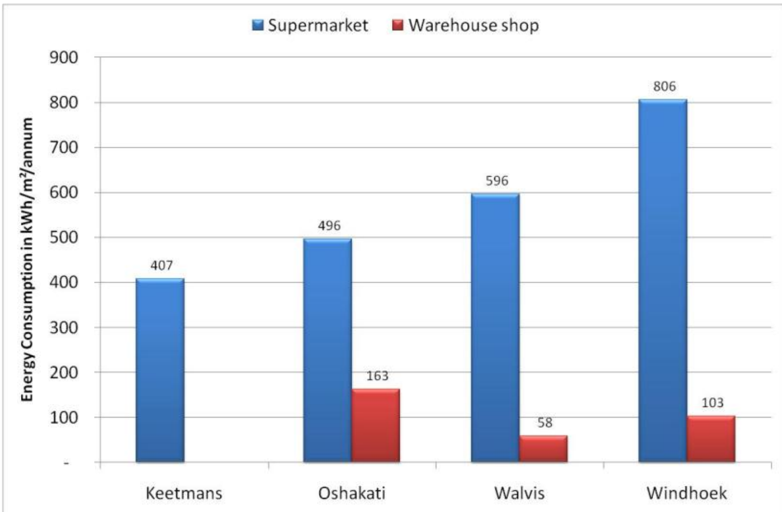
- high levels of artificial illumination
- poor daylight utilisation, or no daylight contribution at all
- bakery
- kitchen/restaurant
- cold and freezer rooms
- refrigerated display cabinets and cupboards
- air conditioning of entire shop floor
-

In contrast, Warehouse Shops often use daylight very effectively, and use substantially less energy intensive equipment than Supermarkets.

Table 8: Large Shops - Average energy consumption in kWh/m²/annum

Locality	Supermarket	Warehouse shop	Average
Keetmans	407		407
Oshakati	496	163	385
Walvis	596	58	488
Windhoek	806	103	665
Average	600	122	494

Figure 4: Large Shops - Average energy consumption in kWh/m²/annum



The reason for regional differences in energy consumption is not clear. Climatic differences are ruled out in this case, as Oshakati and Keetmanshoop should exceed energy consumption for Walvis Bay, which has the coolest climate. The differences might be as a result of a combination of differing levels of business activity, different facilities, technologies employed and varying operation and management patterns.

The regional differences between Warehouse Shops are not significant. It is suspected that the small number of these shops in the sample contributes to this unexpected effect.

Table 9 provides a detailed breakdown of the Large Shops energy benchmarks, with averages per locality and per shop type. There is a large difference between the lowest supermarket (Pick-n-Pay Family Supermarket Walvis Bay, 226 kWh/m²/annum) to the highest (Shoprite Independence Ave. Windhoek, 1,080 kWh/m²/annum).

Table 9: Large Shops - Detailed energy benchmark in kWh/m²/annum

Locality	Supermarket	Warehouse shop	Average
Keetmans	**407**		**407**
JJ's Supermarket, Keetmans	472		472
Nuwe Welcom SPAR, Keetmans	343		343
Oshakati	**496**	**163**	**385**
CTM Oshakati		22	22
GAME Oshakati		304	304
Oshakati SPAR	552		552
Pick-n-Pay Family Store Oshakati	592		592
Shoprite Oshakati	544		544
Woermann Brock Oshakati	297		297
Walvis	**596**	**58**	**488**
CTM Swakopmund		58	58
Pick-n-Pay Family Store Walvis	226		226
Protea SPAR, Walvis	725		725
Shoprite Walvis Bay	764		764
Woermann Brock Walvis	667		667
Windhoek	**806**	**103**	**665**
CTM Windhoek		103	103
Maerua SuperSPAR, Windhoek	711		711
Model Pick-n-Pay Wernhil, Windhoek	625		625
Shoprite Independence Ave., Windhoek	1,080		1,080
Woerman Brock Ae-Gams, Windhoek	807		807
Average	**600**	**122**	**494**

4.2.1.2 Offices (G1) energy consumption

The following observations apply regarding average energy consumption for Offices:

1) Public office facilities use less energy than Private offices. Contributors may include:
    a. Less air conditioning coverage to public offices, particularly in localities other than Windhoek.
    b. Fewer IT equipment and other electronic services in public offices compared with private offices.
    c. Lower occupancy levels in public buildings.
    d. Less attention to repairs and maintenance in public buildings[8], resulting in unserviceable air conditioning equipment and burnt-out lamps.
    e. Differing activity levels between private and public office buildings.

    In Windhoek, however, the sampled public offices on average show slightly higher energy consumption than private offices.

2) Windhoek offices, on average, show a two to three times higher (or even more) energy consumption than offices in other centres. This suggests that offices in the regions are not treated as "generously" in terms of occupant density, air conditioning, IT equipment provision and attention to repairs and maintenance.

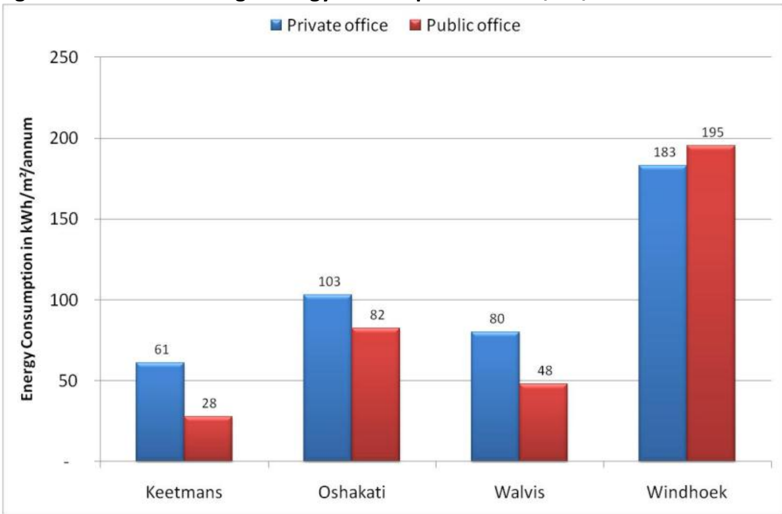
Table 10 and Figure 5 show the average energy consumption for Offices in the private and public sectors.

Table 10: Offices - Average energy consumption in kWh/m²/annum

Locality	Private office	Public office	Average
Keetmans	61	28	36
Oshakati	103	82	91
Walvis	80	48	61
Windhoek	183	195	189
Average	122	88	102

[8] This comment is based on the authors' extensive experience with the renovation of existing public buildings, from which it is clear that regular scheduled maintenance is severely lacking. Readers are encouraged to visit public buildings around Namibia to ascertain this for themselves.

Figure 5: Offices - Average energy consumption in kWh/m²/annum



Again, as in the case of the Large Shops, the regional differences are not simply explained by climatic factors. While the energy consumption in offices in Oshakati is higher than in Walvis Bay, as expected, it is just under one-half that of office buildings in Windhoek, despite Oshakati having a warmer climate than Windhoek. The Walvis Bay energy consumption exceeds that of Keetmanshoop, despite being a cooler climate.

Table 11 provides a detailed breakdown of office energy benchmarks, with averages per locality and public/private. There is a substantial range in results, from 16 kWh/m²/annum (Agriculture Building, Keetmanshoop: no air conditioning, no computers, and minimal occupancy) to 256 kWh/m²/annum (Nedbank Business Centre, Windhoek: high occupancy, poor orientation, poor building envelope, and fully air conditioned).

Table 11: Office - Detailed energy benchmark kWh/m²/annum

Locality	Private office	Public office	Average
Keetmans	**61**	**28**	**36**
Agriculture Building, Keetmans		16	16
Karas Regional Council Office, Keetmans		42	42
Keetmanshoop Municipal Offices	61		61
Ministry of Finance, Keetmans		25	25
Oshakati	**103**	**82**	**91**
Customs and Excise, Oshakati		116	116
Home Affairs Oshakati		19	19
Ministry of Finance, Oshakati		113	113
Oshakati Civic Center	100		100
Oshakati Premier Electric	106		106
Walvis	**80**	**48**	**61**
Customs Building, Walvis Bay		45	45
Erongo RED HQ, Walvis	97		97
Fisheries Inspectorate, Walvis		43	43
Ministry of Finance, Walvis		55	55
Walvis Bay Civic Centre	63		63
Windhoek	**183**	**195**	**189**
Brendan Shimbwaye, Windhoek		190	190
Ministry of Finance, Windhoek		219	219
Ministry of Home Affairs, Windhoek		177	177
Mutual Tower, Windhoek	104		104
Nedbank Business Centre, Windhoek	256		256
Sanlam Centre, Windhoek	189		189
Average	**122**	**88**	**102**

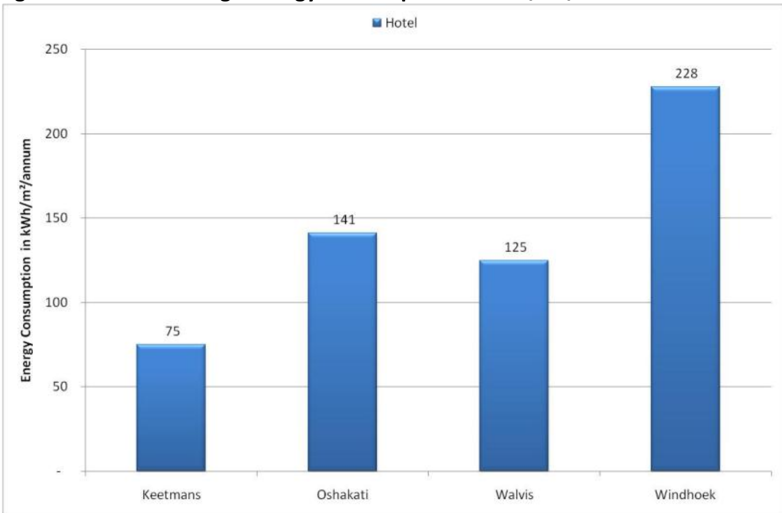
4.2.1.3 Hotel (H1) energy consumption

Hotel energy consumption distribution is skewed towards higher average energy consumption in Windhoek than in the other localities. Hotels reveal a range of different facilities, from simpler bed & breakfast or budget hotels, to more luxurious establishments with conferencing, banqueting and casino facilities.

Table 12: Hotel - Average energy consumption in kWh/m²/annum

Locality	Hotel
⊞ Keetmans	75
⊞ Oshakati	141
⊞ Walvis	125
⊞ Windhoek	228
Average	148

Figure 6: Hotel - Average energy consumption in kWh/m²/annum



The more luxurious hotels, with higher occupancy and higher levels of related activities and services including casino, conferencing and banqueting tend to be concentrated in Windhoek, which explains why Windhoek shows the highest average energy consumption in the Hotel category. The Walvis Bay hotels are also generally more active, with auxiliary functions, which may explain why Walvis Bay and Oshakati are roughly equivalent [9], despite Walvis Bay having a cooler climate than Oshakati. The Keetmanshoop and Oshakati hotels

[9] This study has hypothesised that the similarity of the electrical energy consumption in Walvis Bay and Oshakati can be attributed to the longer heating periods required at the coast. However, the data that was collected as part of the study cannot conclusively confirm or reject this hypothesis. It is recognised that Walvis Bay has more heating degree day data than cooling degree days, while Oshakati has more cooling degree day data than heating degree days. However, the study could not find a clear correlation, which can likely be attributed to the aggregation of energy consumers considered in both towns in the present study.

provide less of the auxiliary activities and tend towards simpler B&B trading, with lower occupancies.

There is a broad range of energy consumption figures for Hotels, ranging from 12 kWh/m²/annum (Oshakati Guest Hotel: low occupancy, B&B plus restaurant) to 398 kWh/m²/annum (Windhoek Country Club Resort: casino, banqueting & conferencing, multiple busy restaurants, extensive pool facilities, likely inefficient water heating and air conditioning systems).

Table 13: Hotel - Detailed energy benchmark kWh/m²/annum

Locality	Hotel
⊟ Keetmans	**75**
Birds Mansions Hotel, Keetmans	69
Central Lodge, Keetmans	100
Schutzenhaus Guest House, Keetmans	56
⊟ Oshakati	**141**
Afrika Stadt Haus Hotel, Ongwediva	63
Hotel Destiny, Oshakati	180
Oshakati Country Hotel	309
Oshakati Guest Hotel	12
⊟ Walvis	**125**
Casa Mia Hotel, Walvis	125
Langholm Hotel Garni, Walvis	62
Protea Hotel Pelican Bay, Walvis	187
⊟ Windhoek	**228**
Auas City Hotel, Windhoek	211
Hotel Thule, Windhoek	36
Kalahari Sands Hotel, Windhoek	258
Windhoek Country Club Resort	407
Average	**148**

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4.2.1.4 SANS 204 comparison

SANS 204-1, Energy Efficiency in Buildings, stipulates maximum energy consumption rates. Table 14 compares the SANS consumption rates to the average survey results for large shops.

Table 14: Large shops - Energy consumption and comparison with SANS 204, in kWh/m²/annum

Locality	Supermarket	Warehouse shop	Average	SANS 204	Supermarket Variance
Keetmans	407		407	240	41%
Oshakati	496	163	330	245	51%
Walvis	596	58	327	260	56%
Windhoek	806	103	454	240	70%
Average	**576**	**108**	**342**	**246**	**57%**

While warehouse shops are well below the maximum stipulated by SANS 204, Supermarkets exceed SANS 204-1 by a substantial margin. Keetmanshoop supermarkets would have to achieve energy savings of 41%, and Windhoek supermarkets would have to drop 70% of their present energy consumption in order to meet the SANS 204 stipulated maximum energy values. While energy efficiency savings are no doubt possible, savings of 40-70% are improbable. It is noted that the single maximum value per climatic zone for “F1 Large Shops” as stated by SANS 204 would appear to be an over simplification, as large shops have vastly differing functions, as illustrated by the difference in energy consumption between warehouse shops and supermarkets.

Research performed on 40 “retail buildings” in Cape Town (C Martin, 2011)[10] returned an average energy consumption of 259 kWh/m²/annum. The report indicated that 40% of retail buildings sampled were below the SANS 204 benchmark level.

Table 15: Office - Energy consumption and comparison with SANS 204, in kWh/m²/annum

Locality	Private office	Public office	Average	SANS 204	Private Office Variance
Keetmans	61	28	44	200	-228%
Oshakati	103	82	93	190	-85%
Walvis	80	48	64	210	-162%
Windhoek	183	195	189	185	-1%
Average	**107**	**88**	**98**	**196**	**-84%**

The average office energy consumption benchmarks for Namibia are well below the maximum values stipulated in SANS 204-1. Given that some sophisticated office buildings in Windhoek achieve energy consumption values of around 100 kWh/m²/annum, we consider the SANS 204 maximum values to be on the generous side. There are, however, a number of office buildings that exceed the SANS 204 values.

Research findings on 41 office buildings in Cape Town (C Martin, 2011) resulted in an average of 188 kWh/m²/annum, while 44% of the office buildings sampled were below the SANS 204 benchmark level. This research result is similar to Namibian office buildings.

Table 16: Hotel - Energy consumption and comparison with SANS 204, in kWh/m²/annum

Locality	Hotel	SANS 204	Variance
Keetmans	75	650	-765%
Oshakati	184	585	-218%
Walvis	125	600	-380%
Windhoek	227	600	-164%
Average	**153**	**609**	**-298%**

Namibian Hotels on average operate well below the SANS maximum energy consumption values. The highest individual hotel energy consumption rate recorded is around 400 kWh/m²/annum.

It must be noted that SANS 204 maximum values were determined based on simulations of “notional buildings” of each occupancy, applied to the various climatic zones. (Holm D et al, 2007). SANS 204 thus assumes that buildings must naturally comply with indoor comfort levels, indoor air quality and lighting levels requirements. Many of the sample buildings in this study do not necessarily comply with all of these requirements.

[10] In the referenced research whole “shopping centres” are aggregated. The study area refers to “rentable” floor area based on Municipal data, with adjustment made for storage and parking area by dividing gross floor area by 1.25 to achieve a net floor area estimate.

Figure 7: Comparison of energy benchmark results with SANS 204

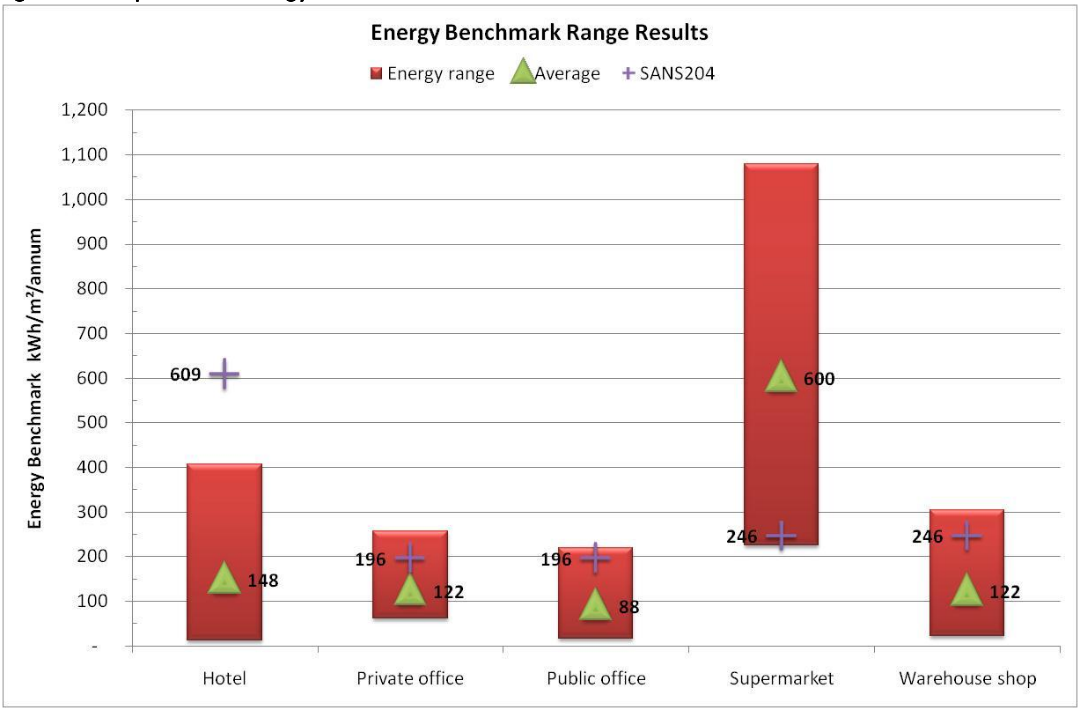


Figure 7 shows the energy benchmark result ranges and their average compared with the SANS 204 stipulated maximum value for that building occupancy. The SANS 204 values have been averaged across the four different climatic zones.

Clearly for hotels the SANS 204 maximum value is too lenient compared to actual building values, as even the most energy intensive hotel falls well below the SANS 204 maximum.

The SANS 204 values are towards the high end of the office results. This does not present too much of a challenge for office buildings to comply with SANS 204.

Supermarkets are a special case of the large shops' occupancy class. Clearly supermarkets are high energy consumers and the results show a broad range of supermarket energy benchmark values. The SANS 204 maximum value for large shops is at the bottom end of supermarket's energy consumption.

Warehouse shops are another special case of the large shops occupancy. Warehouse shop energy consumption compares more favourably with the SANS 204 maximum energy value, which suggests that this type of occupancy is more likely what is contemplated by the large shops' occupancy benchmark.

4.2.2 Demand benchmark

Electrical demand is a measure of instantaneous power drawn by a consumer. Demand is measured in VA (Volts x Amps). The VA value is continuously monitored and the maximum in any given month is recorded. A punitive tariff is charged for the maximum demand exceeding pre-determined limits, which is the case for larger electrical supply connections.

Electrical demand is important to power generation, as the capacity of power stations must match the demand at all times. As new generation capacity is expensive, the intention of maximum demand charges is to encourage consumers to manage or move their load to off-peak periods. The interested reader is – for example – referred to the Namibian demand-side study referenced in the Reference section.

While demand does not represent any value to the consumer, reduction of demand benefits the consumer in terms of dollar savings.

Not all of the buildings in the sample have demand meters installed, so the demand benchmark sample is smaller than in the case of energy consumption. In some cases, where demand meters are installed, the supply authority charges a fixed historical or "stated" demand value. As this does not represent actual demand values these cases are also excluded from the analysis.

SANS 204-1 tabulates "maximum energy demand [11]" in VA, defining it as: "The maximum demand shall be based on the sum of 12 consecutive monthly maximum demand values per area divided by 12 to give the energy demand per month per square metre." The calculated value represents the average maximum demand of the 12 monthly demand values, and not a per month value.

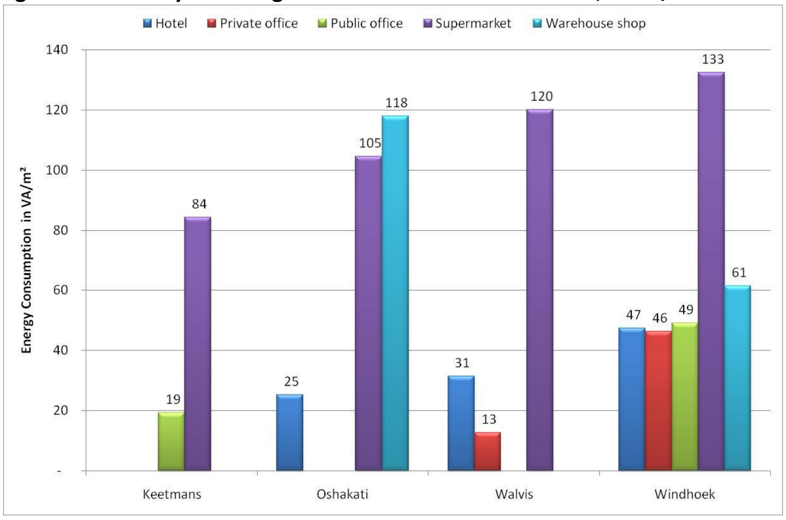
Table 17 lists the average demand for the various building classifications. Where there are blanks there are no sample buildings with any demand metering data. Caution is necessary with interpretation, as in some cases the sample comprises only one or two samples. Figure 8 displays the electrical demand benchmark values graphically.

Table 17: Summary of average electrical demand benchmark, in VA/m²

Locality	Hotel	Private office	Public office	Supermarket	Warehouse shop
⊞ Keetmans			19	84	
⊞ Oshakati	25			105	118
⊞ Walvis	31	13		120	
⊞ Windhoek	47	46	49	133	61
Average	37	38	37	117	90

[11] This report uses the term "demand" and not "energy demand", which can lead to confusion.

Figure 8: Summary of average electrical demand benchmark, in VA/m²



Supermarkets have high demand benchmark figures, which is consistent with their high energy consumption compared to the other building classes.

Many hotels typically use LP gas for cooking and solar or diesel for water heating. Similarly, supermarkets use diesel or paraffin for their bakery ovens and LP gas for restaurant kitchens. The utilization of alternative energy sources assists in the reduction of the electrical demand.

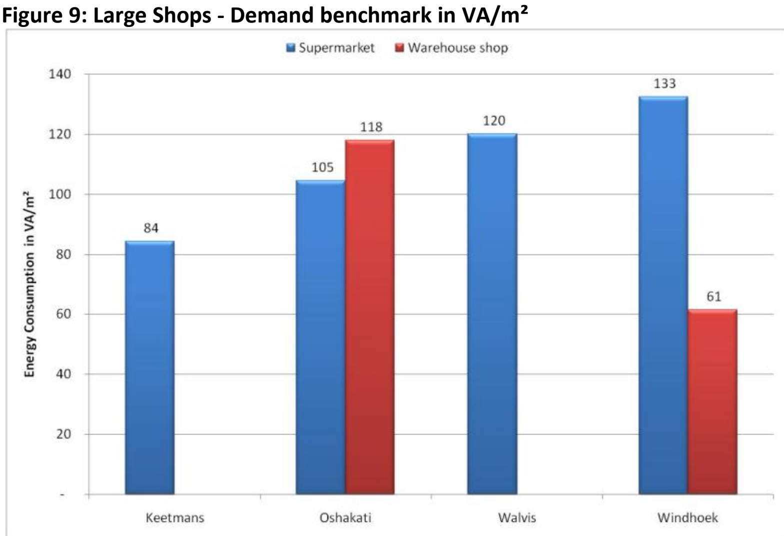
4.2.2.1 Large Shops (F1) demand

The average electrical demand for supermarkets and warehouse shops is summarised in Table 18, and shown graphically in Figure 9. The warehouse shop data represents only one sample in each case. Overall, the average large shops' demand benchmark is 113 VA/m².

Table 18: Large Shops - Demand benchmark in VA/m²

Locality	Supermarket	Warehouse shop	Average
Keetmans	84		84
Oshakati	105	118	108
Walvis	120		120
Windhoek	133	61	118
Average	117	90	113

Figure 9: Large Shops - Demand benchmark in VA/m²



Climatic factors influencing the demand benchmark are ruled out, as the cooler climate of Walvis Bay exhibits a higher average demand than both Keetmanshoop and Oshakati.

Table 19 provides detail of all of the demand values determined from the Large Shops' buildings that were sampled in the project. Demand values range from 61 VA/m² (CTM Windhoek: warehouse shop) to 166 VA/m² (Shoprite Independence Ave., Windhoek), with an average demand of 113 VA/m².

Table 19: Large Shops - Detailed demand benchmark in VA/m²

Locality	Supermarket	Warehouse shop	Average
Keetmans	**84**		**84**
JJ's Supermarket, Keetmans			
Nuwe Welcom SPAR, Keetmans	84		84
Oshakati	**105**	**118**	**108**
CTM Oshakati			
GAME Oshakati		118	118
Oshakati SPAR	110		110
Pick-n-Pay Family Store Oshakati			
Shoprite Oshakati	123		123
Woermann Brock Oshakati	80		80
Walvis	**120**		**120**
CTM Swakopmund			
Pick-n-Pay Family Store Walvis	50		50
Protea SPAR, Walvis	164		164
Shoprite Walvis Bay	148		148
Woermann Brock Walvis	118		118
Windhoek	**133**	**61**	**118**
CTM Windhoek		61	61
Maerua SuperSPAR, Windhoek	135		135
Model Pick-n-Pay Wernhil, Windhoek	128		128
Shoprite Independence Ave., Windhoek	166		166
Woerman Brock Ae-Gams, Windhoek	102		102
Average	**117**	**90**	**113**

4.2.2.2 Offices (G1) demand

The office demand benchmark averages at 37 VA/m². Similar to energy consumption, electrical demand values are lower in other localities when compared with those in Windhoek. This suggests that less air conditioning and office equipment is used in the regions. Note, however, that localities other than Windhoek have few buildings with demand data. Public offices in Windhoek demand marginally more power than private offices.

Table 20: Offices[12] - Demand benchmark in VA/m²

Locality	Private office	Public office	Average
Keetmans		19	19
Oshakati			
Walvis	13		13
Windhoek	46	49	48
Average	38	37	37

Figure 10: Offices[12] - Demand benchmark in VA/m²

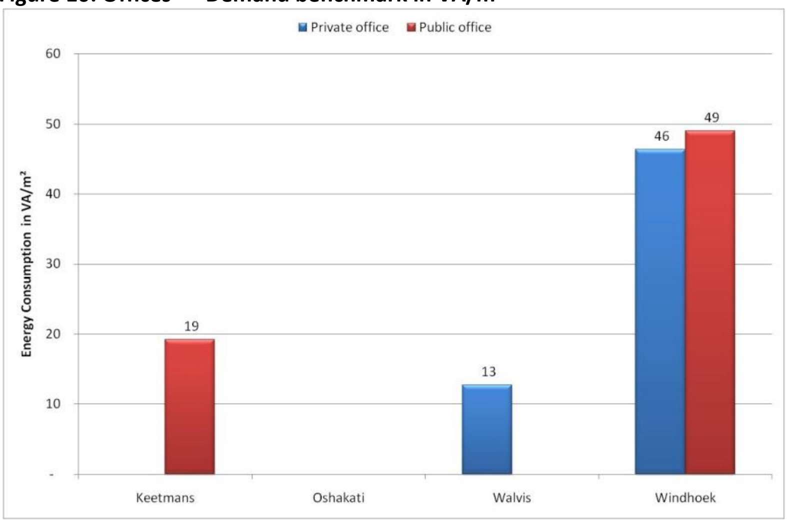


Table 21 provides detail of all of the demand values determined from the Office buildings sampled in the project. Demand values range between 10 VA/m² (Ministry of Finance, Keetmanshoop) to a maximum of 63 VA/m² (Nedbank Business Centre, Windhoek), with a demand average of 37 VA/m². Of interest is the one year old Mutual Tower building in Windhoek, designed as a green building, which has a demand figure of 28 VA/m².

[12] No offices with usable demand data could be identified in Oshakati.

Table 21: Offices[12] - Detailed demand benchmark in VA/m²

Locality	Private office	Public office	Average
Keetmans		**19**	**19**
Agriculture Building, Keetmans			
Karas Regional Council Office, Keetmans		29	29
Keetmanshoop Municipal Offices			
Ministry of Finance, Keetmans		10	10
Oshakati			
Customs and Excise, Oshakati			
Home Affairs Oshakati			
Ministry of Finance, Oshakati			
Oshakati Civic Center			
Oshakati Premier Electric			
Walvis	**13**		**13**
Customs Building, Walvis Bay			
Erongo RED HQ, Walvis			
Fisheries Inspectorate, Walvis			
Ministry of Finance, Walvis			
Walvis Bay Civic Centre	13		13
Windhoek	**46**	**49**	**48**
Brendan Shimbwaye, Windhoek		46	46
Ministry of Finance, Windhoek		58	58
Ministry of Home Affairs, Windhoek		42	42
Mutual Tower, Windhoek	28		28
Nedbank Business Centre, Windhoek	63		63
Sanlam Centre, Windhoek	48		48
Average	**38**	**37**	**37**

4.2.2.3 Hotel (H1) demand

The average demand benchmark value for Hotels across Namibia is 49VA/m². Caution is necessary for average values for Oshakati and Walvis Bay, as each is based on only one sample Hotel. The Windhoek demand average is based on four Hotels.

Table 22: Hotel[13] - Demand benchmark in VA/m²

Locality	Hotel
Keetmans	
Oshakati	75
Walvis	31
Windhoek	47
Average	**49**

Figure 11: Hotel[13] - Demand benchmark in VA/m²

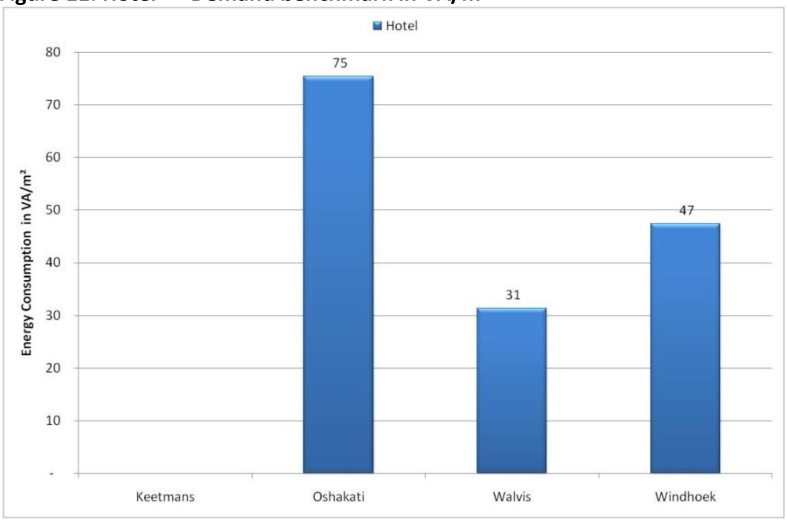


Table 23 lists the demand values determined from the Hotel buildings sampled in the project. Demand values range between 31 VA/m² (Protea Hotel Pelican Bay, Walvis Bay), with the highest being 75 VA/m² (Oshakati Country Hotel).

[13] This study could not identify hotels in Keetmanshoop that had usable maximum demand data.

Table 23: Hotel[13] - Detailed demand benchmark in VA/m²

Locality	Hotel
Keetmans	
Birds Mansions Hotel, Keetmans	
Central Lodge, Keetmans	
Schutzenhaus Guest House, Keetmans	
Oshakati	**75**
Afrika Stadt Haus Hotel, Ongwediva	
Hotel Destiny, Oshakati	
Oshakati Country Hotel	75
Oshakati Guest Hotel	
Walvis	**31**
Casa Mia Hotel, Walvis	
Langholm Hotel Garni, Walvis	
Protea Hotel Pelican Bay, Walvis	31
Windhoek	**47**
Auas City Hotel, Windhoek	53
Hotel Thule, Windhoek	33
Kalahari Sands Hotel, Windhoek	40
Windhoek Country Club Resort	64
Average	**49**

4.2.2.4 SANS 204 comparison

SANS 204-1, Energy Efficiency in Buildings, stipulates maximum demand figures applicable to each building classification according to Climatic Zones. Table 24 compares these values to actual demand benchmark figures obtained for large shops, while Table 25 presents the comparison for offices, and Table 26 for hotels.

Table 24: Large shops – Demand benchmark comparison with SANS 204, in VA/m²

Locality	Supermarket	Warehouse shop	Average	SANS 204	Average Variance
Keetmans	84		84	90	-7%
Oshakati	105	118	111	85	24%
Walvis	120		120	95	21%
Windhoek	133	61	97	85	12%
Average	**110**	**90**	**103**	**89**	**14%**

It is noted that the benchmark values for large shops exceed the maximum value specified in SANS 204-1.

Table 25: Offices – Demand benchmark comparison with SANS 204, in VA/m²

Locality	Private office	Public office	Average	SANS 204	Average Variance
Keetmans		19	19	80	-317%
Oshakati				75	
Walvis	13		13	85	-569%
Windhoek	46	49	48	75	-57%
Average	**30**	**34**	**27**	**79**	**-197%**

The average demand benchmarks for offices are lower than the maximum values stipulated by SANS 204-1. Even the highest benchmark demand value recorded, i.e. 63 VA/m² (Nedbank Business Centre, Windhoek), is well within the maximum value stipulated by SANS. This may suggest that the maximum values stated in SANS 204-1 are possibly too high for Namibian climatic zones.

Table 26: Hotel – Demand benchmark comparison with SANS 204, in VA/m²

Locality	Hotel	SANS 204	Average Variance
Keetmans		90	
Oshakati	75	85	-13%
Walvis	31	95	-203%
Windhoek	47	85	-79%
Average	**51**	**89**	**-73%**

Hotel demand benchmarks are well below the maximum values stipulated in SANS 204-1. The highest hotel demand benchmark determined, i.e. Oshakati Country Hotel at 75 VA/m², is still below the SANS 204-1 specification.

Figure 12: Comparison of electrical demand benchmark results with SANS 204

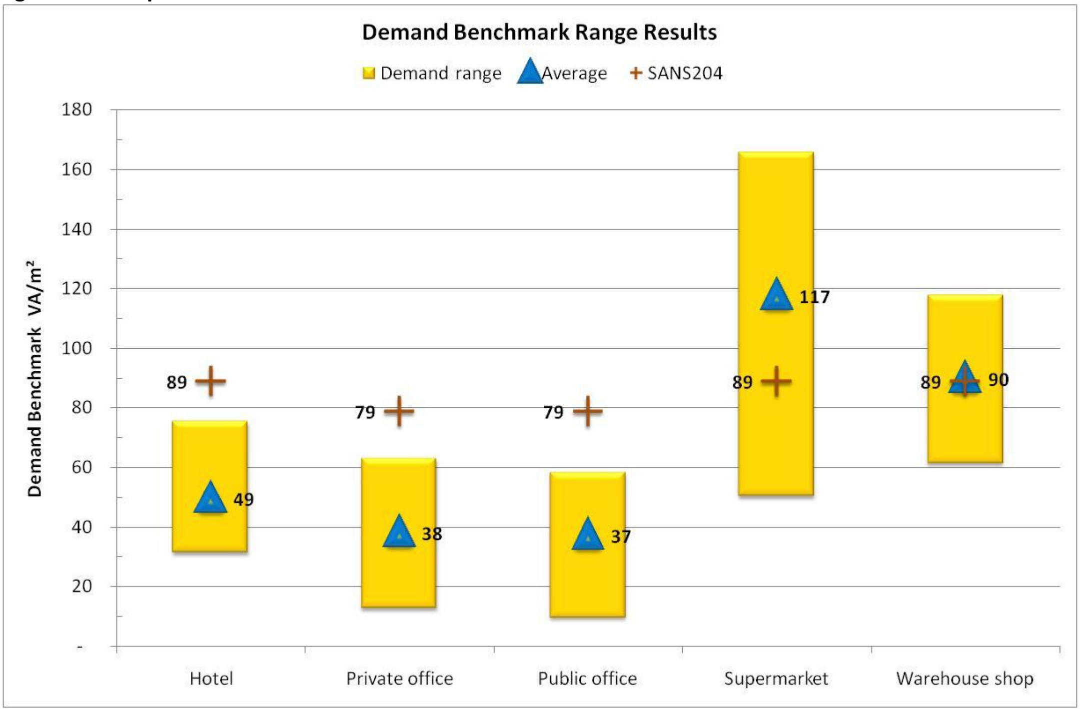


Figure 12 shows the demand benchmark result ranges and their average compared with the SANS 204 stipulated maximum value for that building occupancy. The SANS 204 values have been averaged across the four different assumed climatic zones.

For hotels and offices the SANS 204 maximum value is too lenient compared to actual building values, as even the highest demand facilities fall well below the SANS 204 maximum.

Supermarkets, as a special case of the large shops' occupancy class, exhibit a higher demand on average than SANS 204. Supermarkets exhibit a broad range of demand benchmark values.

Warehouse shops are another special case of the large shops' occupancy. The average demand for warehouse shops is equal to the SANS 204 maximum value, which suggests that this sub-type of occupancy is more likely what is contemplated by the large shops' occupancy.

4.2.3 Hotel occupancy benchmark

The study has looked at an alternative energy consumption and demand benchmark that may be of use for the hospitality industry. Here, the energy consumption and demand values for hotels have been benchmarked as a function of the number of bed-nights sold. This provides a benchmark which is related to hotel activity. Figure 13 compares the previous m² area benchmark values with the new energy consumption per bed-night benchmarks, while Figure 14 compares the demand per m² area benchmark values with the new demand per bed-night benchmark.

Figure 13: Comparison of two hotel energy consumption benchmarks

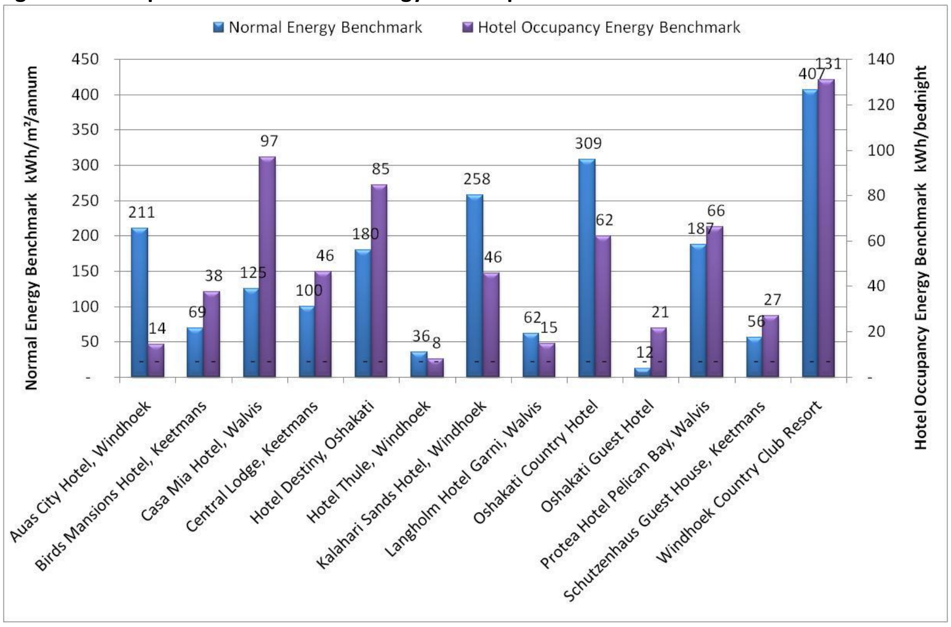
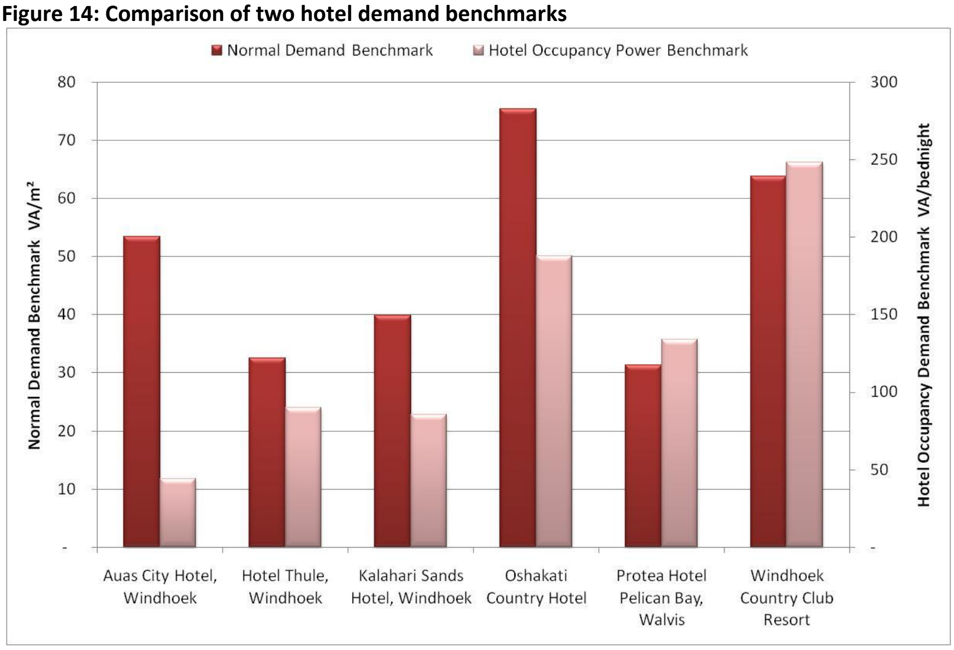


Figure 14: Comparison of two hotel demand benchmarks



As shown in Figure 13, the Central Lodge Keetmanshoop and Kalahari Sands Hotel have similar hotel occupancy energy benchmark values, which are to be contrasted with very different energy per m² benchmark values, which is due to the different occupancies and service offerings between the two.

As shown in Figure 14, the Kalahari Sands Hotel and Hotel Thule have similar hotel occupancy demand benchmarks, but different m² demand values.

Occupancy has an indirect effect on the m² benchmark. While a hotel will have base energy consumption with zero occupancy, each bed sold will add to the base energy consumption plus the electrical demand. The hotel occupancy benchmark relates directly to the primary business purpose of a hotel. A proviso applies that hotels with energy consumed by additional auxiliary functions will exhibit a higher hotel occupancy benchmark value than a hotel which does not.

It is noted that the hotel occupancy benchmark is of relevance for the hospitality industry. The bednight benchmark data is, understandably, of less relevance to the electricity supply industry, who prefer the more relevant electrical consumption and maximum demand benchmarks.

4.3 Assessment of the level of efficiency of buildings

While benchmarking of existing buildings provides a valuable insight into the present status of energy consumption, what represents an efficient or in-efficient energy consumption level for different building classes?

Efficiency is defined as "the ratio of the output to the input of any system". In terms of energy this means that a function is performed more efficiently if it can be done with less energy input.

The benchmarking exercise highlights that there is no simple one-size-fits-all energy consumption benchmark level that can easily be labelled as "efficient". This assertion is supported by:

- The Large Shops classification having widely differing energy consumption between Supermarkets and Warehouse shops, and among various Supermarkets.
- The Offices category shows a broad range of energy consumption.
- Hotels offering different levels of services cannot be compared with each other.

A simple regional public office building with no air conditioning, no IT equipment, limited occupancy and only a few incandescent lamps (those that have not burnt out yet) comprising the only energy consumption does not necessarily constitute energy efficiency. In contrast, a large office building containing a high density of highly productive personnel, by necessity requiring artificial ventilation and heating/cooling, may have a high energy consumption figure but contributes far more to the well-being of the occupants, the organisation and society in general.

Efficiency is not necessarily served by merely reducing the service offerings to reduce energy consumption. This implies that the productive use of energy, in contrast to the absolute use of energy, is a more relevant indicator of how efficiently electrical energy is used.

The simple regional public office building <u>and</u> the sophisticated high-rise office tower both may be the most economical means of operation for their particular circumstances and needs.

Energy efficiency means that in each individual case, the most efficient means of providing the same or very similar levels of service, comfort and function of each building is realised. Essentially each building competes with itself in terms of energy efficiency. However, benchmarking of <u>similar buildings</u> is necessary to provide a means of comparison, which implies that the <u>similarity</u> of buildings and their productive uses is key when undertaking such comparisons.

The SANS 204 standards attempt to specify maximum energy consumption levels. However, it is clear that where some actual buildings appear highly efficient (such as in the case of Offices) compared to the standard, others appear highly inefficient (e.g. Supermarkets). Thus two aspects are important:

1) Building classifications should be expanded and better defined to allow an improved comparison between similar buildings.
2) The maximum energy and demand levels specifications should be reviewed.

The benchmarking exercise nevertheless provides some clear cases of similar buildings exhibiting efficient and less efficient energy consumption. For example:

1) Supermarkets:
    a. Shoprite Independence Ave., Windhoek: 1080 kWh/m²/annum.
    b. Pick-n-Pay Wernhil, Windhoek: 625 kWh/m²/annum (40% less).

2) Offices:
    a. Nedbank Business Centre, Windhoek: 256 kWh/m²/annum
    b. Sanlam Building, Windhoek: 189 kWh/m²/annum (26% less)
    c. Mutual Tower, Windhoek: 104 kWh/m²/annum (59% less than highest).

3) Hotels:
    a. Windhoek Country Club Resort & Casino: 398 kWh/m²/annum
    b. Kalahari Sands Hotel & Casino: 260 kWh/m²/annum (35% less).

The above anecdotal evidence suggests that substantial energy efficiency improvements on less efficient buildings are very likely, while improving an already efficient building may be less viable.

The individual contributors towards building energy efficiency are discussed in the sections that follow, based on the sample survey of buildings in Namibia.

4.3.1 Utilisation of energy sources

Various energy sources are available to choose from:

- Grid electricity
- Solar PV energy
- Solar thermal energy
- Wind energy
- Diesel
- Paraffin
- LP Gas
- Bio-energy

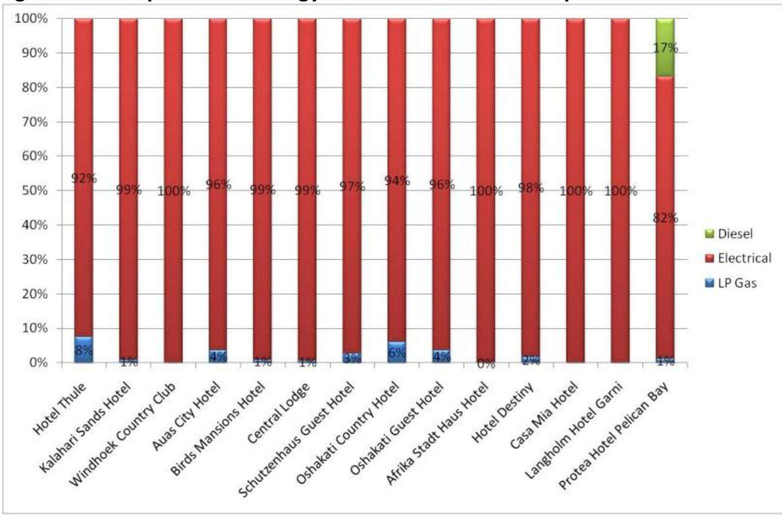
The predominant energy source is grid electricity. However, evidence of the use of all of other listed energy sources were identified, with the exception of wind energy:

- Solar PV energy is used for a cold room at the Oshakati Guest Hotel[14].
- Solar thermal energy is used for solar water heating.
- Diesel is used for ovens, mainly bakery ovens.
- Paraffin is used for a bakery oven at Maerua SuperSPAR, Windhoek.
- LP Gas is widely used for cooking in kitchens.
- Wood is occasionally used, for example in pizza ovens. This study did not quantify the amount of wood used in such establishments, and also did not find evidence of other bio-energy use (for example biogas).

The use of alternative energy sources in addition to grid electricity is common for hotels and supermarkets. The choice of LP gas for cooking, instead of electricity, is likely based more on the economic efficiency than on the calorific efficiency of the process. The main benefit of an alternative fuel source is that they offset maximum demand charges on the electricity account. The decision to use such technologies, therefore, is most likely based on immediate cost economics rather than on energy efficiency considerations. Here it is noted that the use of alternative energy sources remains a potential choice in that it is likely to reduce the maximum demand and contribute to lower energy costs in the longer term.

[14] Note that a kWh equivalent energy value is not available for solar energy in this study, as metered solar PV and solar thermal data is not available.

Figure 15: Comparison of energy sources used in the sampled hotels

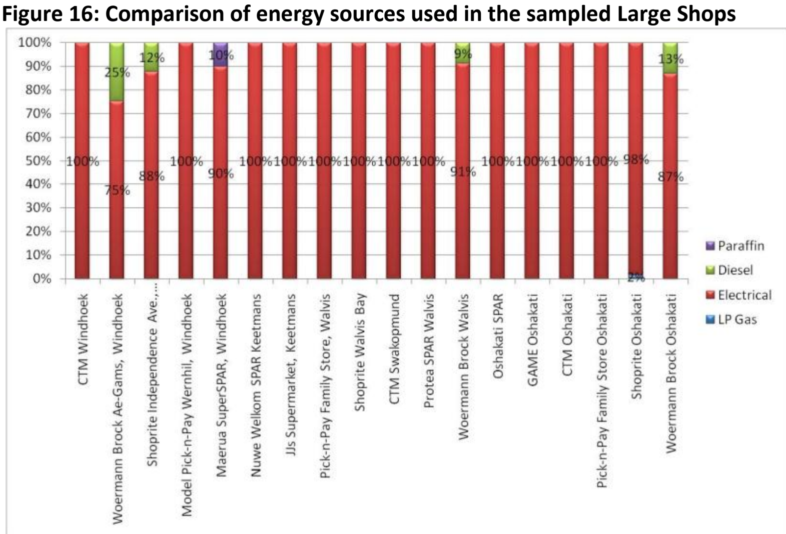


Where hotels use LP gas for cooking, on average gas represents only 2% of their total kWh energy consumption. For Hotel Thule, LP gas consumption in the kitchen comprises 8% of the total energy consumption.

Protea Hotel Pelican Bay uses a diesel boiler for water heating. Diesel comprises 17% of their energy mix, and this is reflected in their low maximum demand 32 VA/m² (Hotel average 58 VA/m²) and favourable load factor of 0.93. However, a feasibility study completed by Emcon for Protea Hotels in 2007 indicated that diesel was not the most economic water heating energy source at the time. The report predicted that the addition of a solar water heating component, while retaining the diesel boiler for boosting, had a cheaper life-cycle-cost, with a breakeven of 5.5 years.

Using solar thermal energy is the most energy efficient means to heat water. However, it is necessary to prove economic benefit before there will be a transition to solar by any hotel. The building sample has too few hotels (only one) using solar water heating to establish any trend, but feasibility studies as part of an energy audit process are expected to prove the business case for solar thermal equipment in future.

Figure 16: Comparison of energy sources used in the sampled Large Shops



A number of supermarkets use diesel or paraffin for their bakery ovens. For Woermann Brock Ae-Gams, diesel comprises 25% of their energy mix. On average, diesel or paraffin comprises 12% of energy consumption for those who use fossil fuel energy.

Table 27 lists the energy consumption benchmarks for supermarkets that have bakery ovens. The average for those that use fossil fuels for ovens (diesel and paraffin) is 687 kWh/m²/annum, compared with 539 (22% less) for those that use electrical ovens. It would appear that the use of fossil fuels is not necessarily energy efficient. It may be that using fossil fuels is beneficial for economic reasons, for example due to maximum demand cost savings and the reliability of services as a result of the diversification of input sources. However, the efficiency and economics of bakery ovens would have to be investigated in greater detail to determine their net cost and energy savings contributions, as the benchmarking energy consumption aggregates all energy consuming processes occurring within the buildings.

Table 27: Supermarket oven energy source benchmark comparison kWh/m²/annum

Building	Diesel	Electrical	Paraffin
Maerua SuperSPAR, Windhoek			711
Model Pick-n-Pay Wernhil, Windhoek		625	
Nuwe Welcom SPAR, Keetmans		343	
Oshakati SPAR		552	
Pick-n-Pay Family Store Oshakati	592		
Pick-n-Pay Family Store Walvis		226	
Protea SPAR, Walvis		725	
Shoprite Independence Ave., Windhoek	1,080		
Shoprite Oshakati	544		
Shoprite Walvis Bay		764	
Woerman Brock Ae-Gams, Windhoek	807		
Woermann Brock Oshakati	297		
Average	**664**	**539**	**711**

4.3.2 Building envelope and orientation

The building envelope is the main contributor to the thermal energy consumption of a building. The SANS 204 standards provide guidelines for the appropriate treatment of the building envelope and orientation, without being very prescriptive.

Qualitative data on the building envelope was collected during the survey. However, this qualitative data is mainly for record purposes, and cannot be used for in-depth analysis. Observations based on anecdotal evidence can however be made from the survey.

The worst performing office building in terms of energy [15] is interpreted to have a sub-optimal building envelope comprising substantial glazed areas, most of it facing virtually due East and due West without shading.

Emcon has previous energy benchmark data for office buildings with excessive exposed glazing where the energy benchmark values are 266 kWh/m²/annum and 230 kWh/m²/annum. Unfortunately these buildings did not respond to the invitation to join the NEEP project.

Figure 17: Building orientation compared to energy benchmark

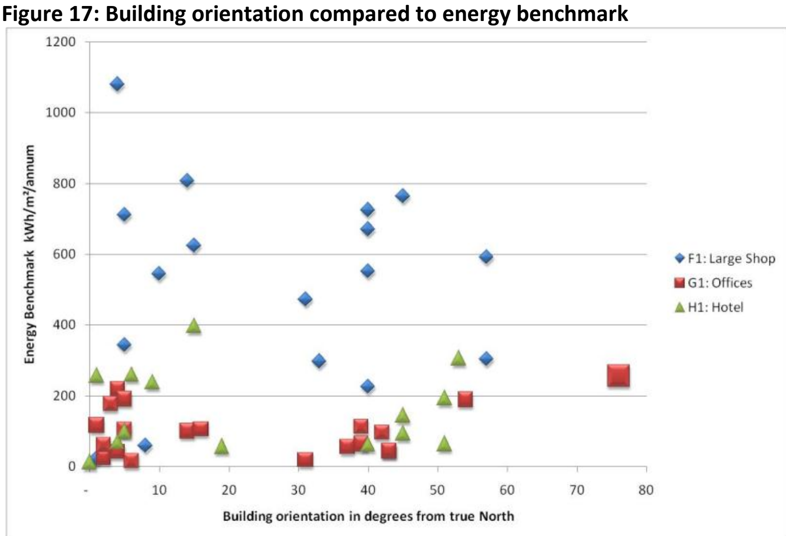


Figure 17 summarises the data points of building orientation compared with their energy benchmark. Large shops are frequently either buried within a shopping centre or have no fenestration[16], making considerations in regard to their orientation irrelevant. In contrast, hotel and office buildings do have fenestration, which implies that orientation is often important to reduce exposure of the fenestration and larger wall area to solar heat gain. The comparison of orientation to energy benchmark does not show a clear correlation, because of aggregation of energy consuming processes. The oversized office data point, refer to the right hand side of Figure 17, however, represents the worst performing office building,

[15] Nedbank Business Centre, Ausspannplatz, Windhoek, 256 kWh/m²/annum, 63 VA/m².
[16] i.e. glazed windows

where the building envelope and orientation are likely to be the main contributors to high energy consumption.

The building envelope is a critical component of building design. Incorrect design decisions are unfortunately hard-wired into the building's 'genetic code'. Remedial measures are possible, but the cost of such remedial action on building envelopes is often prohibitive. It is therefore crucial that building envelope considerations are determined at the time of design. In our experience, the vast majority of building design is completed without any thermal analysis being carried out to determine the thermal performance of the building. If any single design component of a building requires careful design in order to get it right first time, it is the building envelope.

The SANS 204 standards make provision for pre-construction thermal analysis to evaluate the life-cycle costs of a building. Thermal design should be made as important as structural integrity. Building planning approval should make building envelope performance calculations a compulsory part of the process, for both natural and artificial environment controlled buildings. The building designers would be obligated to produce documentation to substantiate the anticipated energy and demand benchmark values prior to construction. We are of the opinion that this single measure alone would make the most significant contribution to energy efficiency in new building stock.

4.3.3 Heating, ventilation and air conditioning

Related to the building envelope is artificial environmental control for buildings, comprising cooling, heating and ventilation (air conditioning). In some cases, the use of passive thermal control measures are sufficient, while in other cases, for example for buildings where heat is generated by people and processes within, artificial environmental treatment is necessary.

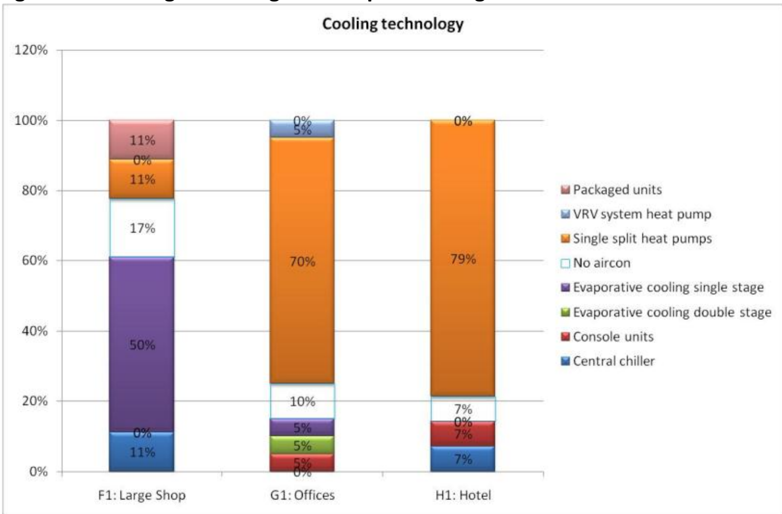
Once artificial cooling or heating becomes a requirement, artificial ventilation is also generally required, as the introduction of uncontrolled external air into the building contributes to increased energy consumption. In Namibia, inland areas require predominantly cooling, while the coast requires very little cooling while some heating is occasionally necessary. Unfortunately, Namibia has no published, reliable, easily accessible climatic data, which implies that it is not possible to substantiate comments on climatic variances and location-specific differences (e.g. Oshakati versus Walvis Bay) using reliable degree-day data. Such data should be provided by the Namibia Meteorological Service.

Traditionally, air conditioning is expected to comprise 70% of the energy consumption of conditioned buildings. The choice of air conditioning technology and control system implementation can have a significant impact on the building's overall energy consumption.

The efficiency of compressor based air conditioning is measured as a co-efficient of performance (COP). A COP of 2 indicates that 1 kWh of electrical energy will supply 2 kWh of thermal cooling capacity. Older and cheaper single split air conditioning units, console-type air conditioning units and old centralised chillers typically operate at a COP of around 2. Newer compressor equipment achieves a COP value of around 4 to 6.

Namibia's generally dry climatic conditions make evaporative cooling a popular choice for cooling. Evaporative cooling typically operates at around 30-40% of the power required by conventional air conditioning. The evaporative cooling process is a natural process using nature's refrigerant (water), and energy is only required to operate a ventilation fan and small water pump. Cognisance must be taken of water consumption considerations when evaporative cooling is considered, as Namibia is also a water-scarce country.

Figure 18: Cooling technologies used per building class



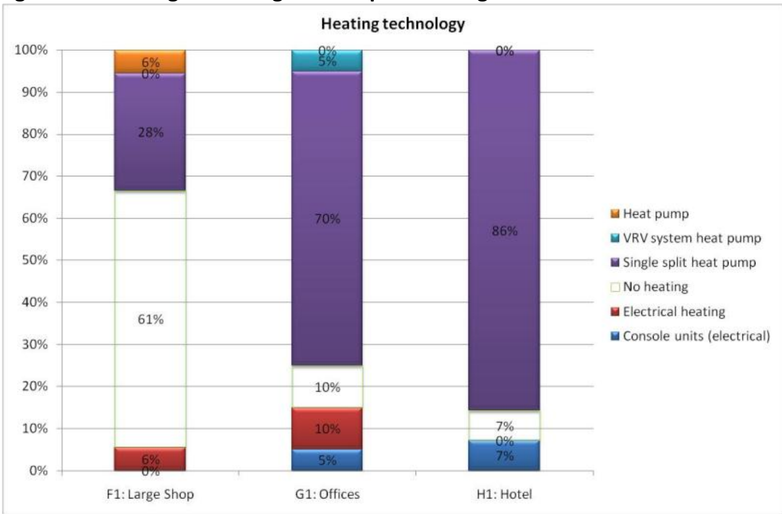
The survey indicates that large shops use mainly evaporative cooling, as evaporative cooling is well-suited to large open spaces. Supermarkets also utilise compressor/refrigerant technology in packaged air conditioning systems, single split units and centralised chiller systems. The supermarket with the lowest energy benchmark figure (Woermann Brock, Oshakati) employs evaporative cooling, while that with the highest energy figure (Shoprite Independence Ave, Windhoek) uses compressor based packaged units.

The predominant air conditioning solution used in office buildings comprises single split units. The lowest energy benchmark building in Windhoek (Mutual Tower) uses double stage evaporative cooling together with some VRV[17] systems.

Hotels utilise mainly independent split units for their air conditioning. While this is not the most energy efficient solution, it has the lowest investment cost, potentially at the expense of life-time energy cost. In general, multiple single split units contribute to high maximum demand, as there is no centralised control over individual compressors.

[17] VRV = Variable refrigerant volume.

Figure 19: Heating technologies used per building class

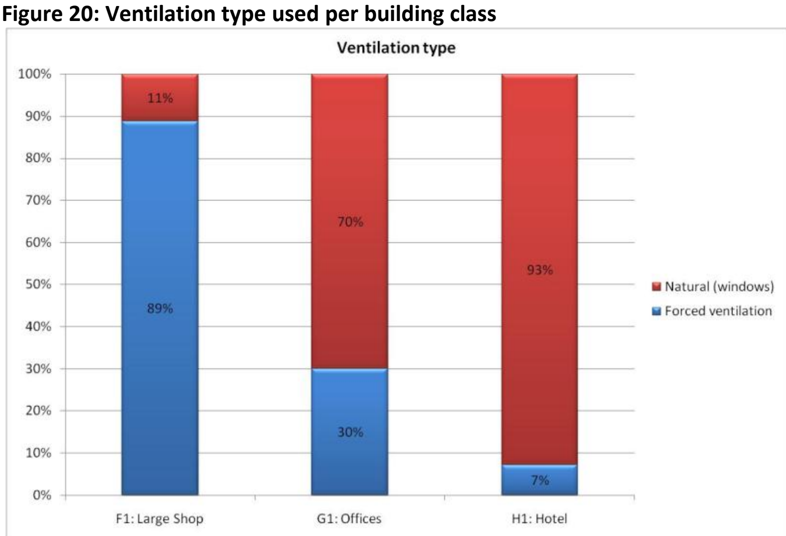


The survey indicates that 61% of large shops are not provided with heating. This is partially due to their predominant use of evaporative cooling, which does not lend itself to a related heating solution as heat pump equipment does. In Namibia, large shops can often do without heating.

Offices use mainly single split units (70%), as heat pumps allow for both heating and cooling. Only some 5% of office buildings are equipped with more efficient VRV systems, while approximately 15% of offices use electrical heating elements (COP of 1.0). The heating requirements in more active office buildings are low compared to their cooling requirements.

Hotels show that single split units are used for heating, with a minority using electrical heating in console units.

Figure 20: Ventilation type used per building class



Building ventilation choices are either natural ventilation (openable windows) or forced ventilation (fan driven). When buildings are provided with natural ventilation and artificial environmental control, the possibility exists that an uncontrolled portion of the conditioned air is lost to the environment through natural uncontrolled ventilation. The conditioned air is replaced with external air, which then leads to excessive volumes of air requiring heating or cooling. When the wind blows, a pressure differential exists around buildings, which draws substantial amount of air through windows and other openings in the building envelope. Uncontrolled infiltration of air into or out of buildings can account for substantial energy wastage and/or a requirement for higher capacity air conditioning equipment.

In the USA and Australia the standard specified for leakage rates are 1.0 litres/m²/s at a test pressure of 75 Pa in accordance with ASTM E286. Test results in South Africa indicate leakage rates of 4.0 litres/m²/s. Building leakage rates in Namibia are likely to be similar to one another as similar materials and construction methods are used. Air-tightness of buildings with artificial climate control and forced ventilation is therefore important to enhance a building's energy efficiency.

By definition, evaporative cooling generally implies forced ventilation. Close to 90% of large shops apply forced ventilation, in parts due to the fact that many use evaporative cooling, but also because Supermarkets mostly do not have windows and thus require forced ventilation.

70% of office buildings rely on natural ventilation. This raises a concern, as office buildings are predominantly cooled using individual split units. Such units do not provide any ventilation as they purely re-circulate indoor air while they cool or heat it. Thus, many office buildings might waste considerable energy through uncontrolled ventilation.

93% of hotels also rely on natural ventilation and are predominantly conditioned using single split units. In general, hotel design is such that cross ventilation across the building is limited due to closed room doors and rooms which are separated by a central corridor. Thus, hotel energy wastage might not be as much of a problem as for office buildings.

The air conditioning technology identified in the survey suggests that there is significant room for improvement in energy and demand reduction in buildings in Namibia.

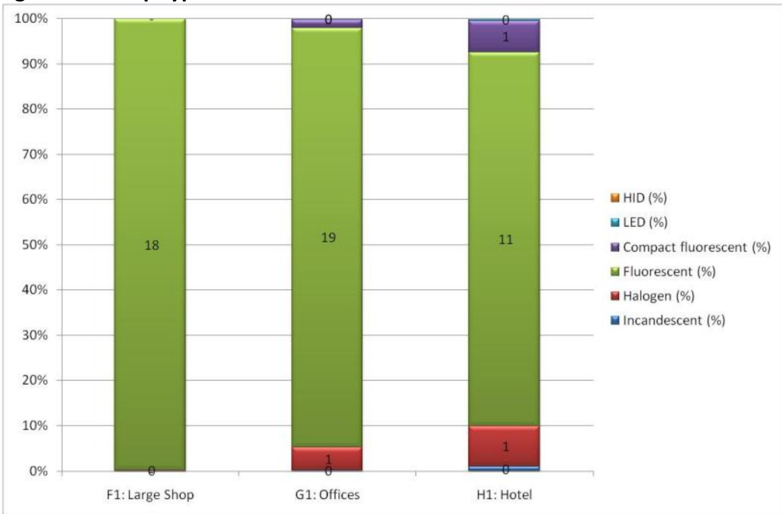
4.3.4 Lighting

Artificial lighting in office buildings is traditionally estimated to comprise between 10 and 20% of maximum demand. Thus, while artificial lighting may not be as significant an energy consumer compared with air conditioning, it does consume sufficient energy to warrant careful attention.

A first-order qualitative evaluation of the distribution of lamp types used in each building was made during each building walk-through, in an attempt to ascertain the general type of lamp technology used. It is emphasised that the approach used would have been more rigorous had proper energy audits been done.

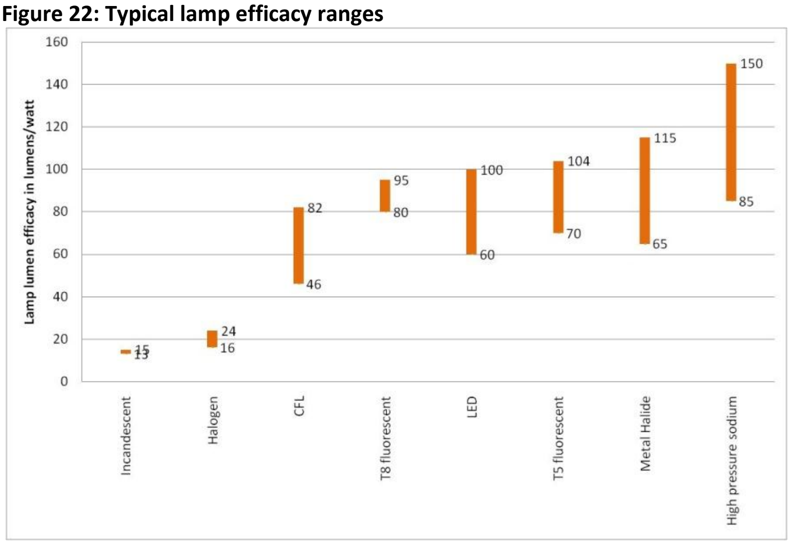
Figure 21, however, suggests that in all building classifications, the predominant lamp technology used is fluorescent, with some Compact Fluorescent Lamps (CFL) . A small number of energy efficient halogen lamps are also used, mainly for architectural lighting purposes. Negligible quantities of Light Emitting Diode (LED) lamps were in evidence, and very small quantities of incandescent lamps were encountered. It would appear that advocacy of CFL and fluorescent lamps as efficient light sources have borne fruit.

Figure 21: Lamp type distribution



The lamp type is the main determinant of lighting efficiency. Lamp output efficiency or efficacy is measured in lumens per watt. Typical lamp lumen efficacy ranges for different lamp types are illustrated in Figure 22. There is a distinct difference between incandescent lamps (which includes halogen lamps) and fluorescent, CFL and LED type lamps. Consideration should not only be given to lamp efficacy, as different lamp types release differing amounts of heat, which contribute to increased internal heat load, which in turn increases the energy consumption of air conditioning equipment.

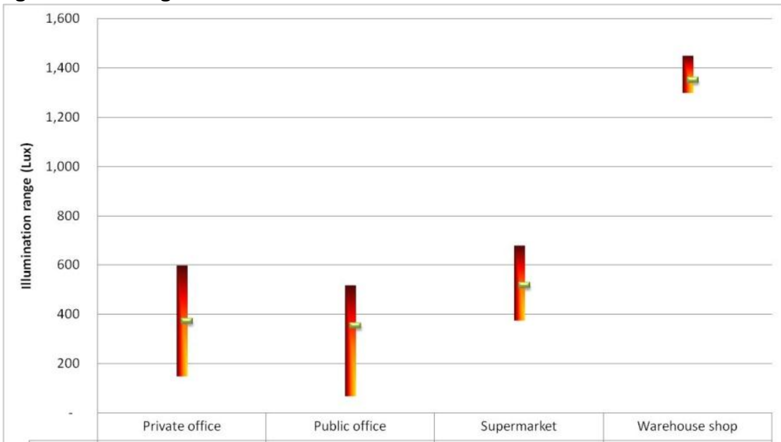
Figure 22: Typical lamp efficacy ranges



In addition to the efficacy of a specific lamp type, the efficiency of the luminaire into which the lamp is installed must be considered. Luminaires provide different efficiencies in terms of the amount of light from the lamp that is directed to where it is required. The lower efficiency luminaires absorb much of the light and are typically cheaper, and for this reason most buildings tend to be populated with lower efficiency luminaires as decisions are made on price rather than on total cost of ownership [18]

The control gear commonly used with fluorescent lamps also contributes to energy efficiency. The trend is towards the use of electronic ballasts for fluorescent luminaires, but while prices of electronic ballasts have dropped in recent years, a price difference remains. If luminaires are purchased purely on price, then they are likely to contain old wire-wound ballasts, which generate more heat, reduce lamp life and result in a sub-optimal power factor. Older buildings, which have not been renovated for some time, usually have older wire-wound ballasts still in operation.

Figure 23: Average illumination levels



	Private office	Public office	Supermarket	Warehouse shop
Max	600	520	680	1,450
Min	150	70	375	1,300
Average	371	353	518	1,350

Illumination was measured within office buildings and large shops. Where possible, illumination measurements were taken deep within the building, where there was little daylight contribution, in order to measure artificial lighting levels.

Offices revealed illuminations levels ranging from 70 – 600 Lux, whereas SANS 10114-1 ("Interior Lighting - Part 1: Artificial Lighting of Interiors") calls for a 500 Lux minimum, with a legislated minimum level of 300 Lux for safety reasons. Common practise, however, suggests that 300 Lux is sufficient, taking into account the widespread use of computer screens. It is alleged that at a level of 300 Lux, vertical and horizontal surface illumination levels are similar, which leads to reduced eye strain for office workers. The average level of artificial lighting in offices from the buildings surveyed appears to be reasonable, while the minimum levels recorded are cause for concern. While it is noted that SANS 10114 is mandatory, its enforcement and the monitoring of compliance is lacking.

[18] The cost of the lamp is usually included in the initial price of the fixture. The purchaser's decision is, in our experience, primarily based on aesthetic considerations, and sometimes on price. Very few purchasers seem to consider life-cycle costs (total cost of ownership), or the type of lamp they are acquiring. On replacing a lamp, purchasers often seem to make their individual purchase decision based on price. It is emphasized however that the present study has not been able to substantiate the above observations with data collected during the study.

Retailers typically call for design illumination levels of 1,000 Lux for effective display of merchandise and improved sales. SANS 10114-1 specifies minimum illumination levels of 500 Lux for large retail areas. The values recorded for supermarkets average just above the minimum, but recorded artificial lighting levels for supermarkets range from 375 to 680 Lux.

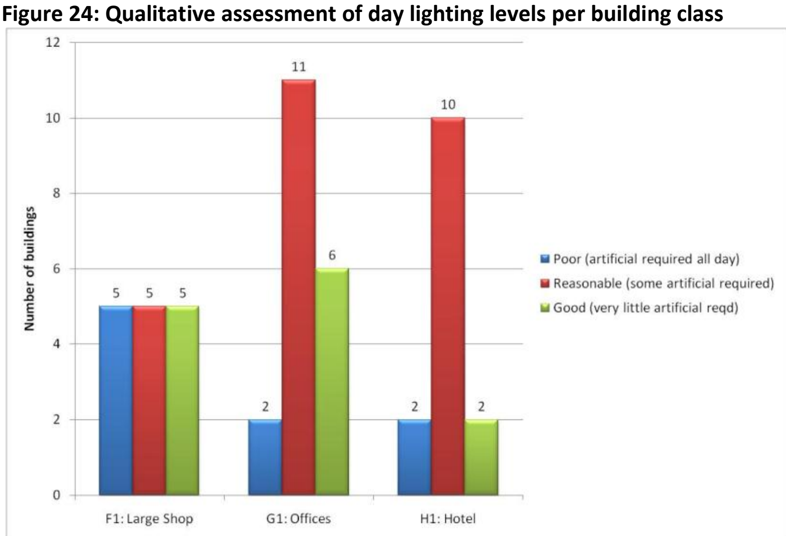
Illumination levels for warehouse shops were taken during working hours and unavoidably include daylight contribution. The warehouse shops include three CTM outlets. The CTM warehouses have significant daylight contributions from generous skylights. At the time of reading, no artificial illumination was operating, so these values represent pure daylight contributions. GAME Oshakati is also classified as a warehouse shop, where artificial lighting was on average measured to be 1,300 Lux.

The survey included a qualitative evaluation of the level of daylight used by the building, with the following classification:

- Poor – artificial lighting required all day
- Reasonable – some artificial lighting required
- Good – very little artificial lighting required

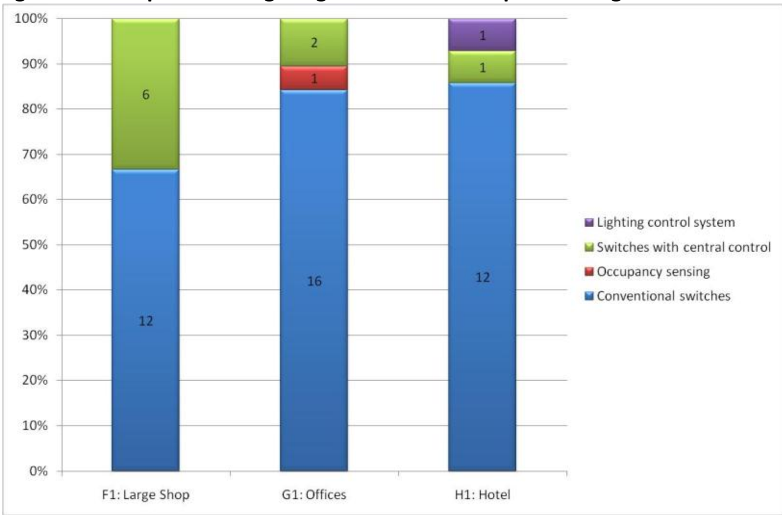
Large shops showed a combination of poor, reasonable and good daylight utilisation. Shops having a 'good' classification were mainly of the warehouse type, having skylights. Supermarket design typically prevents daylight contributions. Supermarkets, naturally those not buried on the lower floors of a multi-level shopping centre, could reduce their artificial lighting energy consumption by allowing controlled day-lighting. Large warehouse shops such as the CTM buildings, seldom require the use of artificial lighting during daytime hours, yet achieve exceptionally high illumination levels. The quality of day-lighting in terms of colour rendering is an added benefit. It is, however, important that day-lighting is achieved without the introduction of too much heat. In general this simply means that direct solar irradiation must be avoided.

Figure 24: Qualitative assessment of day lighting levels per building class



In general, offices exhibit reasonable to good use of illumination. Hotels also allow sufficient daylight into the bedrooms (the room where daylight was evaluated for hotels).

Figure 25: Comparison of lighting control methods per building class



The control of artificial lighting is another area where energy can be saved. Most of the buildings surveyed are furnished with conventional light switches, which make the building occupants responsible for the control of illumination.

An improvement to conventional switching is a central switch from where the majority of lighting can be switched on or off by building occupants.

Only one office building was encountered which incorporated occupancy sensing to control lighting (Mutual Tower, Windhoek), and one hotel has a lighting and air conditioning control system installed for their rooms (Kalahari Sands Hotel, Windhoek).

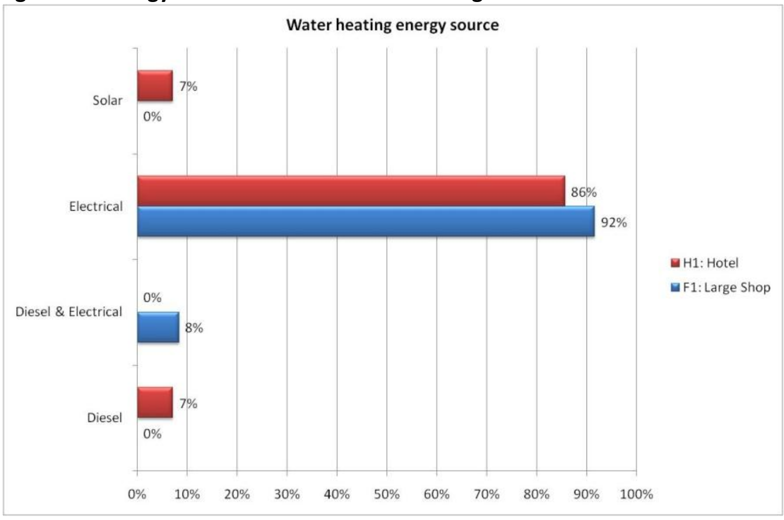
While building owners and operators appear to have migrated to more energy efficient lamp types, there is still considerable scope for energy savings in the area of lighting.

4.3.5 Hot water

The survey results indicate that hotels and large shops predominantly use direct electrical heating for hot water, followed by diesel boilers. Only one hotel uses solar with electrical backup. No evidence was found of heat pumps being used for water heating.

A recent study undertaken by Emcon revealed that solar heating combined with heat pump boosting was the most cost effective means of water heating. Based on interviews with building owners and operators, we judge that few understand the economic benefits of solar water heating.

Figure 26: Energy sources used for water heating



4.3.6 Elevators and escalators

A survey of elevator technology did not form part of this study.

Older elevators use geared or gearless AC induction motors, which drive the elevators against a counterweight on the way up and on the way down. More recent elevator technology has moved towards variable-voltage-variable-frequency drive motors (essentially speed controlled motors) and regenerative elevator technology, both of which save energy. In regenerative elevators, the motor is turned into a generator when the elevator car moves down, which generates power which is fed back into the electrical system and in this way reduces the overall energy consumption. Savings on daily energy consumption of around 50% have been reported when this type of technology is employed.

Elevator technology is seldom renovated, due to high capital cost. Emcon has recently noted an increase in the renovation of 30-year old elevators in public buildings. For high rise buildings with very active but old elevators, and for new buildings, there is likely to be an energy and total cost of ownership benefit when regenerative elevator systems are installed.

4.3.7 Renewable energy sources

Only one case of PV power generation was identified in the survey. Oshakati Guest Hotel has a cold room which is PV powered.

Previous studies have shown that solar water heating is both highly effective and efficient for water heating, and that the total cost of ownership is lower for solar water heating than any other technology at present. It is therefore concerning that only one of the hotels participating in the survey uses SWH.

Namibia's main wind energy resource is located along the coast. No wind energy system was encountered, but wind could easily be a part of on-site renewable energy generation if feasibility can be shown.

Another renewable energy source with future potential is biogas. Hotels have significant water-borne and organic kitchen waste which, if passed through a biogas digester, could likely generate gas which could be used either for cooking or (if viable) for peak power generation.

4.3.8 Appliances

Appliances were not surveyed in detail during the study, as the scope of such work falls into the realm of a detailed energy audit. The energy source for major equipment was surveyed and is reported on in detail below.

The survey did note that there is almost no building without some IT and office equipment such as fax machines, photocopiers, scanners, shredders, cash registers and electronic scales.

Supermarkets are intensive appliance users, as they commonly include kitchens/restaurants, bakeries and butcheries.

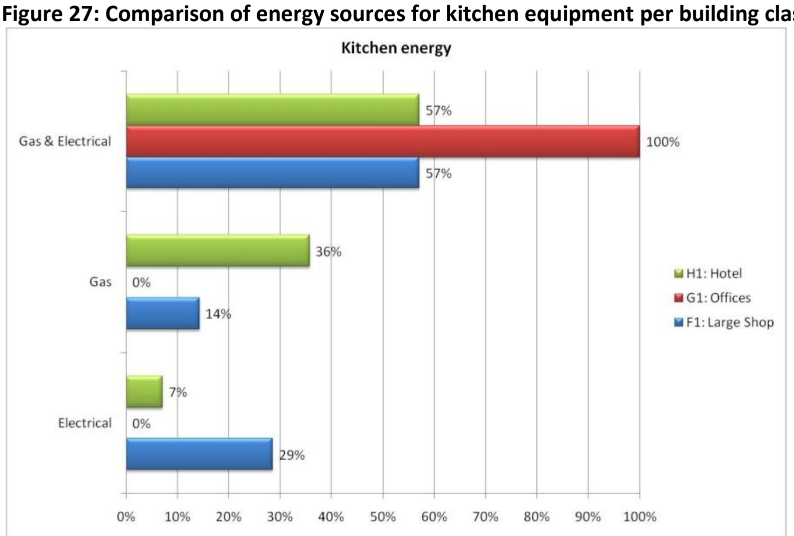
Hotels require a wide range of kitchen equipment, refrigeration and laundry equipment.

The use of more energy efficient appliances and particularly knowledge of the energy implications of technology choices is important.

4.3.8.1 Kitchen equipment

Kitchens use a variety of electrically powered equipment including stoves, ovens, fryers, microwave ovens, steam ovens, can openers, slicers etc. Commonly, cooking appliances apply thermal energy, which implies high energy consumption.

Figure 27: Comparison of energy sources for kitchen equipment per building class



A significant portion of hotels (93%) use LP gas in their kitchens, while only 7% relying solely on electrical appliances. Those using only electrical energy are commonly the smaller hotels. Clearly, gas is the popular choice, because gas cooking is faster and more easily controlled.

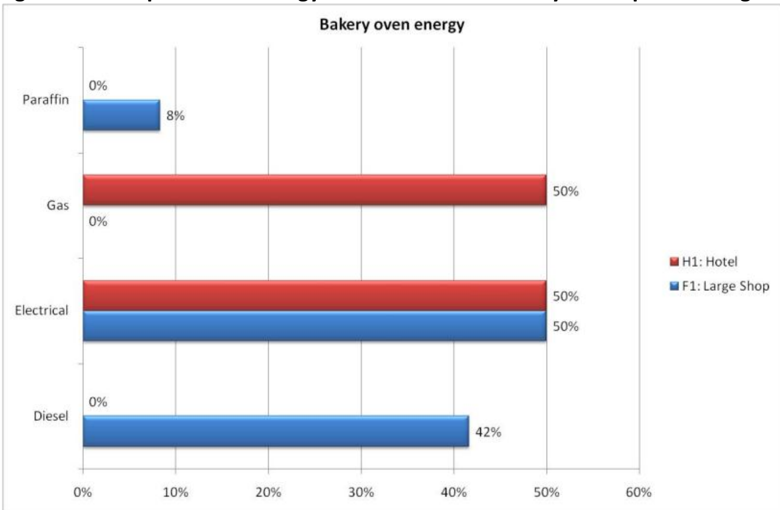
The majority of large shops (71%) use LP gas in their kitchens.

The surveyed sample for offices included only one restaurant (included with the energy consumption in Mutual Tower, Windhoek), which renders the information less useful.

The relative energy efficiency and economics of LP gas vs. electrical cooking appliances needs to be researched for Namibia's specific conditions, and the information made public.

4.3.8.2 Bakery ovens

Figure 28: Comparison of energy sources used for bakery ovens per building class



Hotels and large shops are equally split between the use of electrical or fossil fuel energy sources for baking ovens. The relative energy efficiency and life-cycle-cost comparison between these various fuel sources should be determined. While the process efficiency of ovens remains relatively constant (barring major technology developments), the consumer price of energy sources fluctuates. A life-cycle-costing tool for baking ovens should therefore be developed that can be updated regularly and used for decision making.

4.3.8.3 Laundry equipment

Laundry equipment typically comprises washing machines, tumble driers and ironing equipment.

93% of the hotels surveyed have their own in-house laundries, all of them using electrical energy to power their machines. No data was collected on the energy source for laundry hot water, as it cannot simply be assumed that the hot water energy used in the hotel is the same as that used for the laundry. Some laundries introduce solar or diesel heated hot water

into the laundry machines, while others allow the laundry machines to heat water electrically.
There is a need for detailed investigation into the energy efficiency and economics of laundry operations, as this can be a significant component of a hotel's total energy use.

4.3.9 Power factor correction

Power factor correction is a form of energy efficiency, in that "wasted" energy is reduced. SANS 204-1 specifies that the power factor in buildings should not be lower than 0.95.

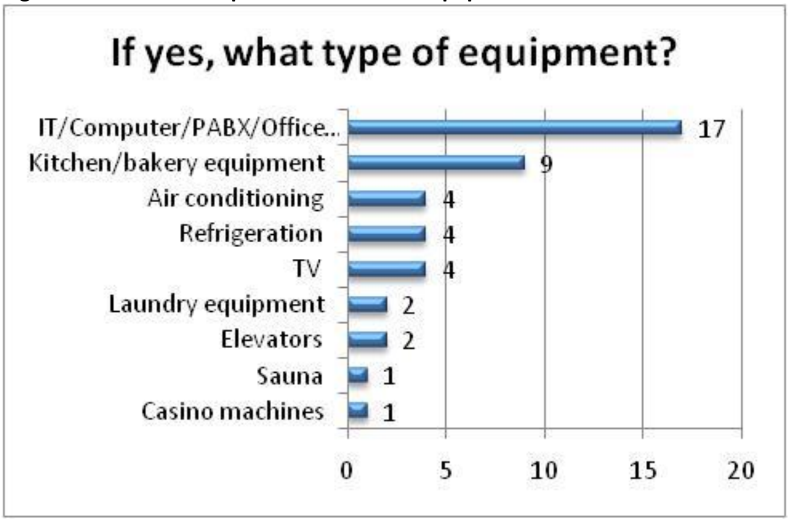
Power factor was not measured for the surveyed buildings, but no evidence of power factor correction (PFC) equipment was noted. This does however not mean that none of the surveyed buildings uses PFC.

Experience shows that power factor correction, when applied to buildings subject to a maximum demand tariff, shows excellent returns on investment.

4.3.10 Future equipment purchases and renovation

Respondents were asked what their immediate equipment purchases and renovation requirements were. The majority (65%) of respondents indicated that they were planning to purchase new equipment in the near future. The answers were grouped into similar equipment categories. Most respondents intend purchasing electronic and cooking equipment.

Figure 29: Intention to purchase electrical equipment

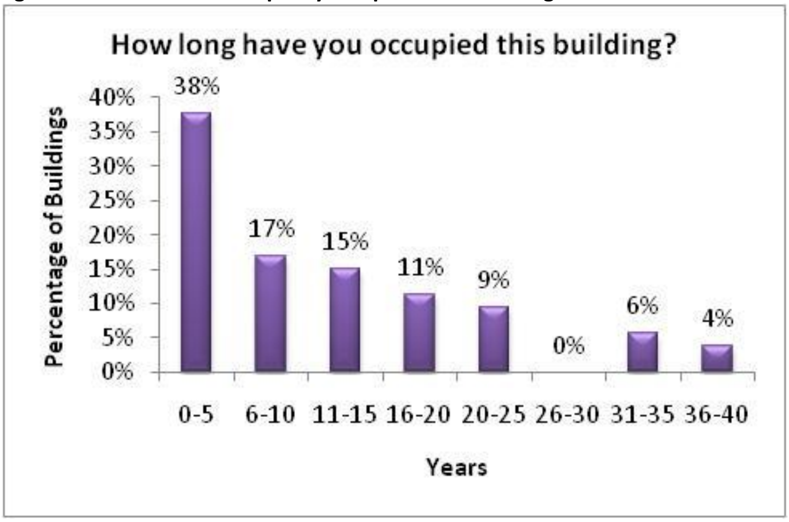


Two thirds (66%) of the buildings surveyed indicated that they were owner occupied. Of those that were tenant occupied, some 82% of the tenants are responsible for the electricity account. Supermarket occupancy is mostly tenanted. A tenant occupied building may represent a barrier to energy efficiency conversions and upgrades, particularly where such conversions or renovations involve substantial investments in fixed assets. The building owners may be satisfied with their rental arrangement, and as the tenant bears the burden of the electricity account, the owner is unlikely to be motivated to invest in energy efficiency measures unless a new rental agreement can be negotiated. Such negotiations are not necessarily straightforward.

Figure 30: Building occupancy by owner or tenant

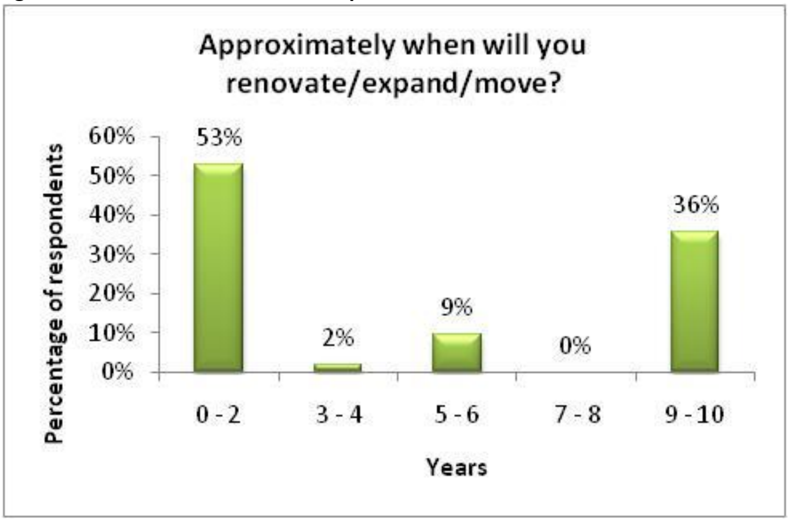
Over half (55%) of the building occupants indicated that they have occupied their current premises for less than 10 years, with the longest building occupancy being 40 years (Walvis Bay Civic Centre).

Figure 31: Duration of occupancy in a particular building



More than half of the respondents have occupied their building for less than 10 years, while just over half intend making changes within the next 2 years. This, despite the fact that the sample includes a significant number of public buildings, suggests that there is a fairly high churn rate.

Figure 32: Intention to renovate/expand/move



4.3.11 Load factor

The load factor is a ratio represented by the average power divided by the peak power, over a given period of time. As such, the load factor provides an indication of the variability of a building's electricity use, with a load factor of 1 indicating that the building operates at a constant load across the monitored time period, and a load factor of 0.50 indicating that the building maximum demand is double the average power consumption rate in the given period.

The load factor for all buildings that have a maximum demand value has been calculated, based on the annual benchmarking figures. Large shops and hotels show similar average load factors of around 0.60, while office buildings have an average load factor of around 0.40. Office buildings exhibit a lower load factor due to shorter operating hours and possibly because most office buildings employ single split air conditioning, which contributes to the variability of the electricity demand.

Normally a high load factor indicates that loads are even and maximum demand charges are being kept to a minimum. For example, Protea Hotel Pelican Bay has a high load factor of 0.93. The use of diesel for water heating and LP gas for cooking, while the climate seldom makes air conditioning necessary, results in fewer demand peaks and reduced demand variability.

Low load factors are experienced by Hotel Thule (0.13) and CTM Windhoek (0.19). In the case of Hotel Thule, the peak load is likely caused by high occupancy rates (all air conditioning operating, laundry operations, functions) in the evening, while over night and during most of the day the consumption of electricity is lower. In the case of CTM Windhoek, the artificial lighting and air conditioning are generally off; only occasionally are they switched on together. In these two cases it is believed that the low load factors result more from good load management, and not as a result of uncontrolled loads.

The load factor as a statistic on its own is not particularly valuable. A building may be highly energy efficient or inefficient, irrespective of the load factor. The load factor, however, is useful as an additional tool to highlight if there is a high maximum demand. Buildings with a low load factor need to check whether load management should be applied to reduce demand.

Table 28: Load factor per building

Building	F1: Large Shop	G1: Offices	H1: Hotel
Auas City Hotel, Windhoek			0.45
Brendan Shimbwaye, Windhoek		0.47	
CTM Windhoek	0.19		
GAME Oshakati	0.29		
Hotel Thule, Windhoek			0.13
Kalahari Sands Hotel, Windhoek			0.74
Karas Regional Council Office, Keetmans		0.17	
Maerua SuperSPAR, Windhoek	0.60		
Ministry of Finance, Keetmans		0.30	
Ministry of Finance, Windhoek		0.43	
Ministry of Home Affairs, Windhoek		0.48	
Model Pick-n-Pay Wernhil, Windhoek	0.56		
Mutual Tower, Windhoek		0.43	
Nedbank Business Centre, Windhoek		0.46	
Nuwe Welcom SPAR, Keetmans	0.46		
Oshakati Country Hotel			0.47
Oshakati SPAR	0.57		
Pick-n-Pay Family Store Walvis	0.51		
Protea Hotel Pelican Bay, Walvis			0.68
Protea SPAR, Walvis	0.51		
Sanlam Centre, Windhoek		0.44	
Shoprite Independence Ave., Windhoek	0.74		
Shoprite Oshakati	0.50		
Shoprite Walvis Bay	0.59		
Walvis Bay Civic Centre		0.57	
Windhoek Country Club Resort			0.73
Woerman Brock Ae-Gams, Windhoek	0.91		
Woermann Brock Oshakati	0.42		
Woermann Brock Walvis	0.64		
Average for Building Classification	**0.54**	**0.42**	**0.53**

4.3.12 Opportunities for improved energy efficiency

The survey has only considered three common building classifications, and the total sample size of 52 buildings is small. However, the results show that some buildings use between 26% and 60% less energy than comparable inefficient buildings.

Based on the results of the survey it is concluded that there exist substantial opportunities for improvements to energy efficiency in Namibia's public and private building sector.

In considering energy efficiency improvements, attention must be given to all building types and not only the three included in this benchmarking study. Also, attention must be given to the substantial existing building stock, as well as any new construction in any attempt to improve the overall energy efficiency of buildings. Existing buildings are typically only renovated every 10 to 30 years, averaging at around 20 years, with an average building life of 80-100 years (Holm D et al (2007)). Such renovations seldom target obsolete technology such as lighting, elevators and air conditioning, although the life of mechanical equipment is typically 15-20 years. It is therefore imperative that efficiency conversions of existing building stock are accelerated, as waiting for the next 10-20 years for technology changes will be costly.

The mix of where real energy saving opportunities will be found is specific to each individual building, but relatively common to similar occupancy groups. The sections above, and common energy audit practise, suggest where to apply energy efficiency measures most cost-effectively, and look for inefficient practises.

In addition to the technology-specific energy efficiency measures discussed in the sections above, there are a host of interventions which are possible which involve little or no cost. These relate mainly to operation and maintenance procedures, as well as awareness creation and behaviour changes among building occupants. We observed some simple measures taken by some survey participants, such as hotel housekeeping staff being specifically trained and monitored in respect of switching off unnecessary loads when making up rooms. Such small changes may in their own way contribute to making energy use more productive without necessitating any capital investments.

4.4 Market perceptions of energy efficiency

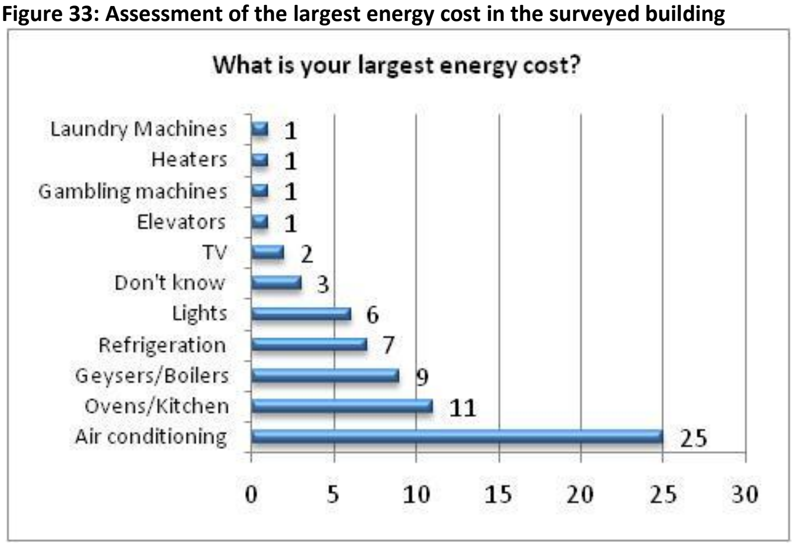
An appropriate management representative for each building was interviewed during the survey to attempt to gain an understanding of the market perceptions on energy efficiency. A series of questions were posed (refer to Appendix 2) to these respondents. The results are presented in this section. It is noted however that the results obtained are generally the personal opinions and perceptions of an individual interviewed and cannot always be backed up by actual fact

4.4.1.1 Understanding of energy charges

58% of the respondents answered that they understand how their electricity tariff is calculated. However, when asked to explain what tariff was being charged, the number who could answer reduced to 32% of the survey sample respondents. It is concluded that only approximately one third of the building operators interviewed understand their electricity tariffs.

Most building operators appear to have a reasonable understanding of what contributes to high energy consumption, as the equipment identified by most respondents typically is the higher energy use equipment. However, only an actual energy audit could determine whether the respondents in fact answered correctly for their facility.

Figure 33: Assessment of the largest energy cost in the surveyed building



4.4.1.2 Energy control measures

Some 45% of respondents claim to have used energy control methods. Of those, most of the energy efficiency measures introduced have been in form of lighting control, which suggests that advocacy for energy efficiency lamp replacement (particularly the CFL advocacy) has had an impact.

Load control measures include hotels house-keeping staff being trained to switch off unnecessary loads when making up rooms. For example, Kalahari Sands Hotel and Casino, has installed an energy management system in their rooms to control lighting and air conditioning loads according to occupancy. Hotel Thule on the other hand has installed solar water heating. Overall though, the survey indicates that attempts to introduce energy efficiency measures remain very limited.

Figure 34: Assessment of the use of energy management systems

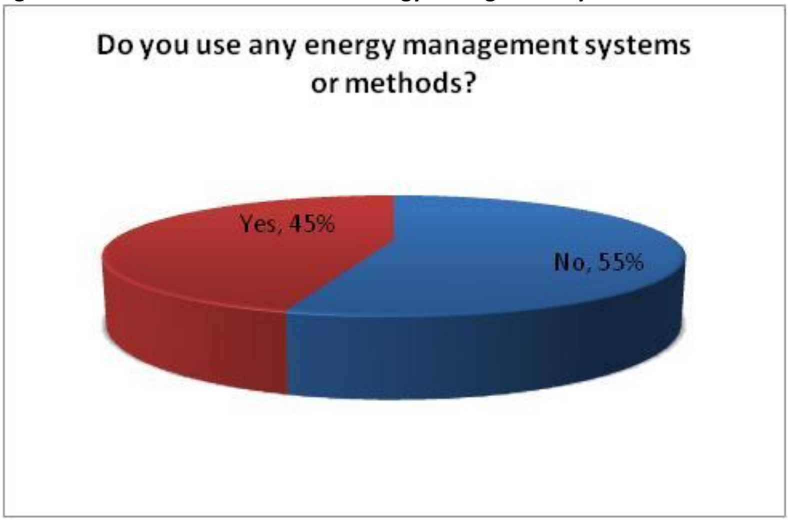
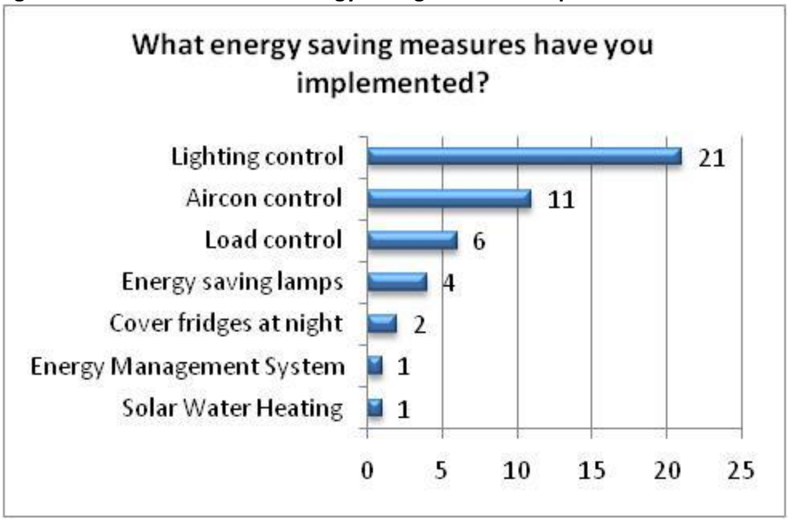


Figure 35: Assessment of the energy saving measures implemented

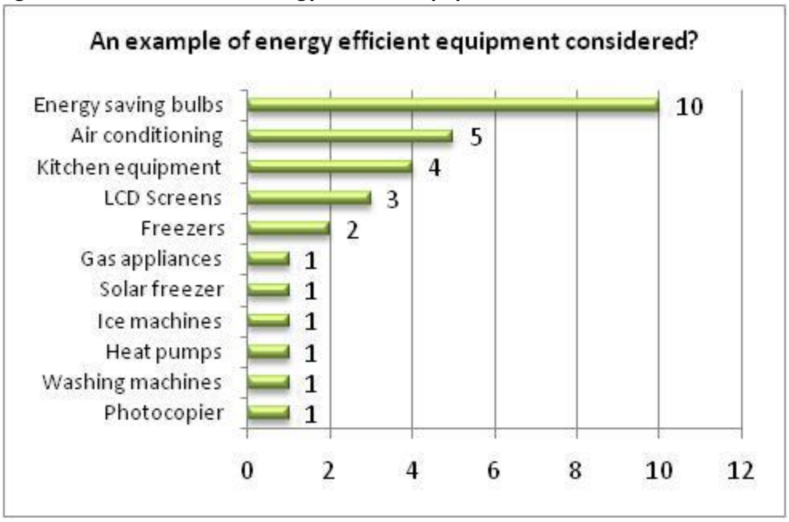


4.4.1.3 Energy efficient equipment purchases

More than one half (55%) of the surveyed respondents indicated that they consider energy efficiency criteria when purchasing new equipment. Of those who responded that they did not consider such criteria, 95% indicated that they would consider energy efficiency if they had clear information available. Thus, there is a need for information on energy efficiency of equipment and appliances.

Those who did consider energy efficiency were asked for examples of the type of equipment which they considered to be energy efficient at the time of purchase. Figure 36 again confirms that the energy saving lamp advocacy initiative has had an impact, while the remainder of technologies and measures on the list includes equipment where energy efficiency often does form part of the purchasing decision process.

Figure 36: Assessment of energy efficient equipment considered



4.4.1.4 Perceptions regarding energy audits

Only 26% of the surveyed respondents have heard of the term "Energy Audit". Of those, 17% (4% of all respondents) are under the impression that they have commissioned an energy audit in the past. Of those again, two respondents claim to have implemented changes as a result of an energy audit.

Those respondents were asked what measures were implemented. From the answers given, it was clear that only 1 out of 50 respondents could provide clear evidence of what may be called an energy audit, i.e. Pick-n-Pay Wernhil Park, Windhoek[19].

It is clear that the majority (74%) of building owners and operators are not aware of the benefits of energy audits.

[19] Subsequently it became apparent that all Pick-n-Pay branches underwent energy audits.

4.4.1.5 Willingness to change

A series of questions were asked to attempt to understand the willingness of building owners and operators to improve their energy efficiency, or their carbon footprint, and their perceptions regarding the associated savings potentials.

Three quarters of the surveyed respondents (77%) believe that their operations are either normal or highly efficient. The breakdown per sector shown in Figure 37 illustrates that large shops (the highest energy consumers) are the most optimistic in regard to their energy efficiency, followed by offices where only 20% believe that their building is inefficient. In the absence of clear information provided by energy audits and comparative benchmarks, building operators will remain ignorant about the actual energy efficiency of their building.

Figure 37: Perception of own building energy efficiency

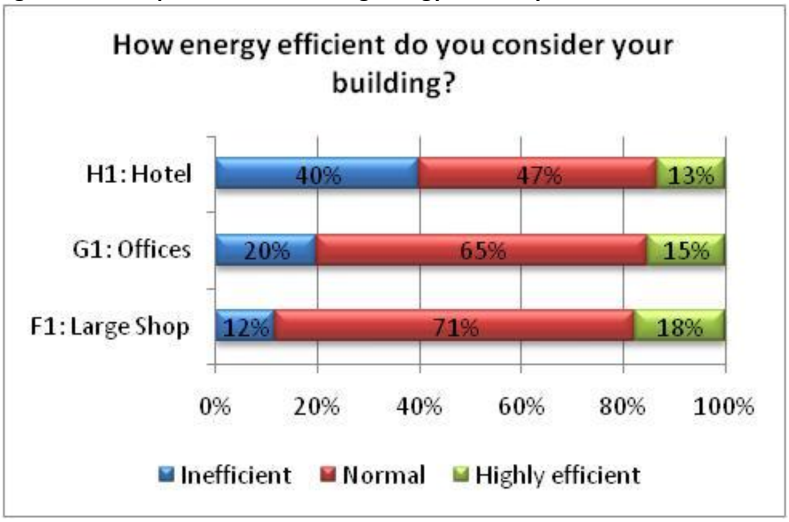
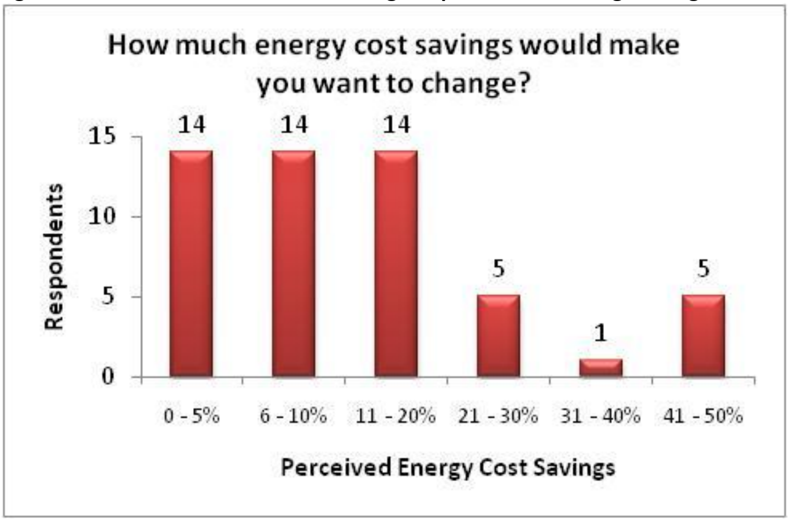


Figure 38 shows the responses to what level of savings would encourage management to decide to change for improved energy efficiency. The majority (83%) of respondents would be happy with up to a 20% dollar cost savings, with some willing to go as low as 1%, with one particular respondent suggesting that even a 1% improvement represents cumulative savings.

It was initially thought that those respondents who wanted to halve their energy costs were unrealistic. As was shown in Section 4.3 however, there is evidence of some office buildings functioning with 60% less energy than clearly inefficient buildings.

Figure 38: Assessment of the cost savings required to encourage change



Only 36% of respondents would be prepared to pay a higher rent for a more energy efficient building. Those who said no (64%) qualified their answer with comments such as:

- "Only for a lot of energy savings".
- "No idea, I don't have clear information".
- "It depends on the rent".
- "No idea about the costs, these are government properties".
- "Depends if feasible economically".

The comments imply that if a clear business case exists for a more energy efficient building, more tenants would likely be prepared to pay more rent for a more energy efficient building.

Some 44% of respondents stated that they would pay a higher rent for a green building, irrespective of cost savings. This is 8% higher than the response to the question above. Unfortunately the additional question of "why?" was not posed. Perhaps there is a perception that "green" means a healthier working environment, perhaps more respondents care about global warming but understand the reality of business decisions, or perhaps respondents recognise the marketing value of operating from a green building.

4.5 Identification of buildings for future energy audits

A list of buildings for which energy audits are recommended is required for the NEEP project. A priority list of buildings has been extracted from the energy benchmark data, based on the following criteria:

a) All buildings with annual energy consumption exceeding the average of their building class are included.
b) The list is prioritised according to their total annual energy consumption (kWh/annum).

The logic behind this approach is to optimise returns for a given investment.

The result is shown in Table 29 for 21 buildings which exceed the average energy benchmark for their class of building, prioritised according to annual energy consumption. Model Pick-n-

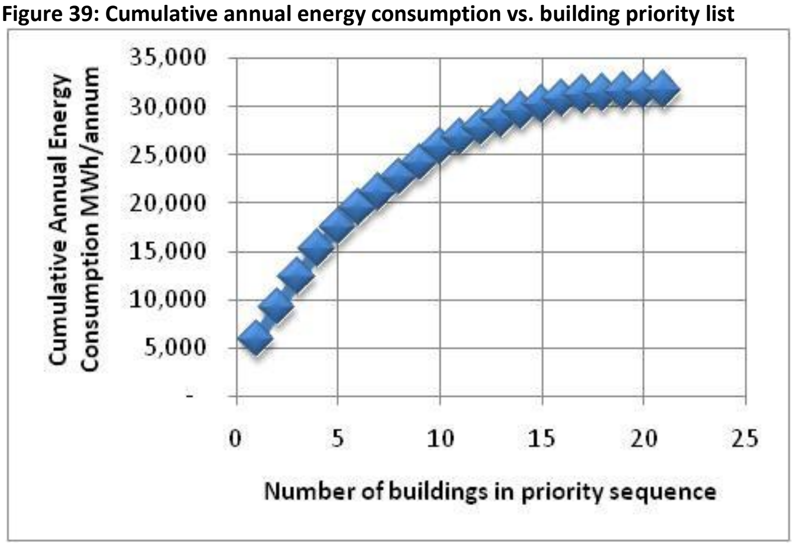
Pay facilities should be excluded from this list as they have already undergone an energy audit and remedial measures are being implemented.

Table 29: Buildings recommended for an energy audit

Priority	Building	Building description	Energy Benchmark kWh/m2/annum	Annual Energy kWh/annum
1	Windhoek Country Club Resort	Hotel	398	5,877,336
2	Kalahari Sands Hotel, Windhoek	Hotel	260	3,250,654
3	Sanlam Centre, Windhoek	Private office	189	3,157,105
4	Model Pick-n-Pay Wernhil, Windhoek	Supermarket	625	2,935,915
5	Maerua SuperSPAR, Windhoek	Supermarket	711	2,248,805
6	Brendan Shimbwaye, Windhoek	Public office	190	1,933,589
7	Shoprite Independence Ave., Windhoek	Supermarket	1,080	1,610,794
8	Woerman Brock Ae-Gams, Windhoek	Supermarket	807	1,573,458
9	Shoprite Walvis Bay	Supermarket	764	1,562,801
10	Ministry of Finance, Windhoek	Public office	219	1,562,262
11	Protea Hotel Pelican Bay, Walvis	Hotel	257	1,054,239
12	Ministry of Home Affairs, Windhoek	Public office	177	964,789
13	Woermann Brock Walvis	Supermarket	667	959,000
14	Protea SPAR, Walvis	Supermarket	725	794,050
15	GAME Oshakati	Warehouse shop	304	672,197
16	Nedbank Business Centre, Windhoek	Private office	256	570,819
17	Oshakati Country Hotel	Hotel	305	402,909
18	Auas City Hotel, Windhoek	Hotel	238	195,314
19	Hotel Destiny, Oshakati	Hotel	193	165,663
20	Ministry of Finance, Oshakati	Public office	113	113,236
21	Customs and Excise, Oshakati	Public office	116	38,827

The cumulative sum of total annual energy consumption per building in priority sequence is presented in Figure 39. The form of the curve illustrates the rate of energy being addressed from the start of the audit sequence. The top 10 buildings (1-11, excluding 4) represent an annual energy consumption of 22.8 GWh. The next 10 buildings (12-21) represent an annual energy consumption of 8.9 GWh. The probability and extent of energy savings on the first 10 buildings expected to be higher than for the next 10 buildings.

Figure 39: Cumulative annual energy consumption vs. building priority list



5 Domestic Benchmarking

5.1 Current electricity demand in the domestic sector

As indicated below, domestic consumption is an important component of total energy consumption. Energy data from a sample of the various regional electricity distributors (REDs) and town supply authorities has been evaluated (based on the local authority tariff structure) to determine how much electrical energy is consumed by residential consumers.

The data excludes large consumers which are normally supplied by NamPower, including mines, and largely excludes rural consumption, thus fairly representing urban energy consumption only. The results presented in Table 30 and Table 31 indicate that around 40% of urban electricity consumption is consumed by domestic customers, which implies that around 60% of urban electricity consumption is of commercial, industrial and institutional nature.

Table 30: Namibian urban energy consumption by supply authority in 2010

Supply authority	Residential MWh	All MWh	Residential %
Northern RED (NORED)	117,366	245,424	48%
Oshakati Premier Electric (OPE)	16,838	53,512	31%
Central-Northern RED (CENORED)	40,239	148,914	27%
Erongo RED	153,881	392,390	39%
Windhoek	328,892	748,184	44%
Mariental	7,504	23,387	32%
Total	**664,720**	**1,611,811**	**41%**

Table 31: Namibian urban energy consumption by locality in 2010

Locality	Residential MWh	All MWh	Residential %
Otavi	1,420	6,490	22%
Kamanjab	360	1,512	24%
Mariental	7,504	23,387	32%
Outjo	2,598	8,080	32%
Grootfontein	6,140	18,396	33%
Walvis Bay	79,677	232,278	34%
Khorixas	1,731	4,710	37%
Tsumeb	9,808	25,032	39%
Otjiwarongo	12,742	31,644	40%
Okakarara	1,157	2,713	43%
Windhoek	328,892	748,184	44%
Usakos	1,954	3,867	51%
Regional Council Areas	1,840	3,575	51%
Swakopmund	52,844	97,211	54%
Henties Bay	6,600	10,306	64%
Karibib	3,632	5,449	67%
Arandis	3,934	5,726	69%
Totals	**522,833**	**1,228,560**	**43%**

In 2010, Namibia's total electricity consumption amounted to approximately 2.7 TWh, including rural consumption and mining, but excluding Skorpion Zinc Mine, exports to neighbouring countries and line losses. The total electricity use in the supply authorities' territories as summarised in Table 30 thus represents almost 60% of Namibia's total electricity consumption in 2010, while the total consumption for the localities summarised in Table 31 constitutes some 46% of the total national electricity consumption in 2010.

5.2 Projected energy service needs in the domestic sector

While it is clear that the existing level of electricity consumption in the domestic sector is significant (representing more than 40% of the electricity consumption in urban areas) it is important to consider the longer-term projections for energy service demands in the domestic sector.

Based on experience in emerging economies internationally, it is expected that there would be a significant increase in domestic energy consumption in Namibia over time, as average household income levels increase. This anticipated trend would be an outcome of the combined impacts of

i. increased delivery of housing,
ii. reductions in energy poverty in low-income households, and
iii. increased penetration of appliances using electricity, especially for lighting and mass media products.

The latter characteristic is sometimes referred to as the 'suppressed demand' for energy services. It is therefore, important to address the energy efficiency opportunities in the domestic (or household) sector in anticipation of the projected increases in income levels, in order to mitigate the associated increase in energy consumption under the 'business-as-usual' approach to energy utilisation in the domestic sector.

5.3 Opportunities for energy efficiency interventions in the domestic sector

While both commercial and residential energy efficiency is important, improvements in energy efficiency in the commercial sector are easier to achieve, mainly for the following reasons:

1) Commercial facilities are larger and have more concentrated energy consumption, whereas domestic consumers are more numerous, with smaller individual energy consumption.
2) The economic benefits of energy efficiency are often more readily demonstrated for commercial buildings.
3) Commercial entities have better access to finance for efficiency upgrades.

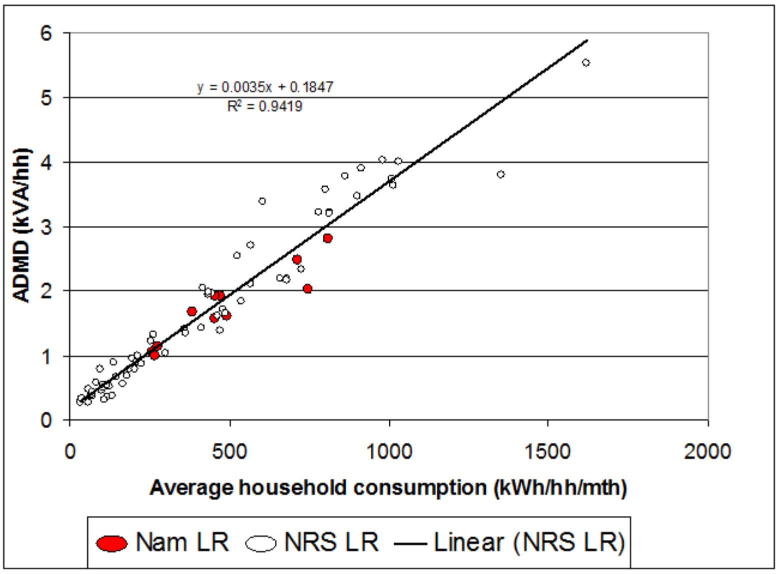
Despite this, there is a large stock of existing residential properties and a consistent housing backlog in urban and peri-urban areas, creating a demand for housing development. It is therefore important that new domestic construction adds thermally efficient buildings in order to avoid future energy consumption and demand problems.

Electricity load research undertaken in Namibia (MME, 2001/2002) assessed the electricity consumption and maximum demand characteristics of a sample of 450 low-, middle- and high-income households in the following four study areas:

- Windhoek A: Wanaheda (low-income)
- Windhoek B: Katutura (middle-income)
- Ongwediva: (middle-income)
- Walvis Bay: Meersig (high-income)

As in the case of international experience, the results from this study revealed a clear relationship between electricity consumption (and maximum demand), and the level of household income. For example, the After Diversity Maximum Demand (ADMD)[20] and consumption data that was extracted from the Namibian load research projects are compared against load research data from South Africa, as shown in Figure 40.

Figure 40: Domestic ADMD vs. consumption in Namibia and South Africa (MME, 2001)



It is therefore important that domestic energy consumption is quantified as well, in order to:

- Understand the distribution and range of domestic energy consumption.
- Evaluate standard housing designs in order to ensure that housing is thermally efficient, while attempting to remain within economic cost constraints.
- Identify the mix of existing energy consuming appliances within the domestic market in order to plan effective and targeted awareness creation programmes.
- Evaluate the efficiency of commonly used domestic appliances and determine whether energy marking of appliances would be beneficial.

[20] ADMD is the after diversity maximum demand and refers to the expected demand for electricity– as measured in kVA – which the electricity distribution network 'sees' from a customer (or a connection) in terms of the demand on the electricity system. The ADMD is based on the combination of the sum of the nameplate demand for all appliances in the customer's facility and a diversity factor which represents the percentage of those appliances which are actually operating simultaneously. The ADMD provides the basis for network design.

The factors which were determined to influence the electricity consumption in the domestic sector in Namibia are highlighted below (MME, 2001).

Table 32: Household factors most strongly associated with differences in household consumption (MME, 2001)

Time period	Most important household factors
Evening peak	• number of rooms in households • utilisation of gas for cooking
Morning peak	• utilisation of hot water storage heaters • size of family
All day consumption	• size of dwellings (Floor area) • use of fridge/freezers

International experience has shown that the most effective approaches to energy efficiency in the domestic sector include:

- Energy efficiency awareness programmes, including access to information and resources.
- Improved design and construction of new housing including:
    - Planning, design and development of thermally-efficient (or so-called passive thermal) housing in publicly funded housing projects for lower-income household.
    - Regulatory requirements for energy efficiency in planning approvals for housing in the mid- and higher-income sectors.
- Energy labelling programmes for appliance efficiency.
- Energy efficiency and demand side management programmes (supported by a regulatory environment for utilities / REDs to set tariffs based on energy efficiency performance rather than the traditional consumption-based revenue/rate of return model).

In practice, energy efficiency standards for buildings in the domestic sector are more difficult to implement within the context of voluntary programmes in the absence of both a concerted awareness programme and an electricity tariff-based incentive scheme. In the publicly-funded housing sector on the other hand there may be scope to use planning approval mechanisms to enforce increasingly higher levels of energy efficiency in housing design and construction.

6 Energy Efficiency Standards

6.1 Context for energy efficiency in buildings

It is useful to understand the context of how energy efficiency considerations can be incorporated into buildings when assessing the applicability of energy efficiency standards for buildings.

Overall, the energy efficiency dimensions of buildings can be considered in terms of the typical lifecycle of buildings. This includes the phases of:

- Concept initiation and feasibility stage activities
- Planning and design
- Construction
- Commissioning and handover
- Leasing and occupation
- Fitout and appliance procurement
- Operation
- Refurbishment and upgrade

The opportunities for influencing the energy efficiency in individual buildings are triggered at certain stages in the building's lifecycle. In addition, the mechanisms and institutional responsibilities for effecting energy efficiency interventions are significantly determined by the roles and responsibilities of the stakeholders involved at these different stages in the building's lifecycle. These realisations emphasise the value of contextualising energy efficiency within the overall typical lifecycle of buildings.

For example, experience in California (CEC, 2005) identified 'trigger points' which could offer opportunities to enforce or influence decisions related to energy efficiency. Examples of these 'trigger points' include:

- the sale of a property
- a change in the leasehold on a property
- the replacement of equipment and components installed on the premises, and
- refinancing, remodeling, renovation or rehabilitation events.

The opportunities for energy efficiency interventions which are 'triggered' by these events are considered to be very useful in the context of applying efficiency interventions in Namibia.

A schematic representation of the typical overall lifecycle of buildings – and the associated opportunities, mechanisms and institutional responsibilities for energy efficiency interventions – is shown in Figure 41.

Figure 41: Energy efficiency within the overall lifecycle of buildings

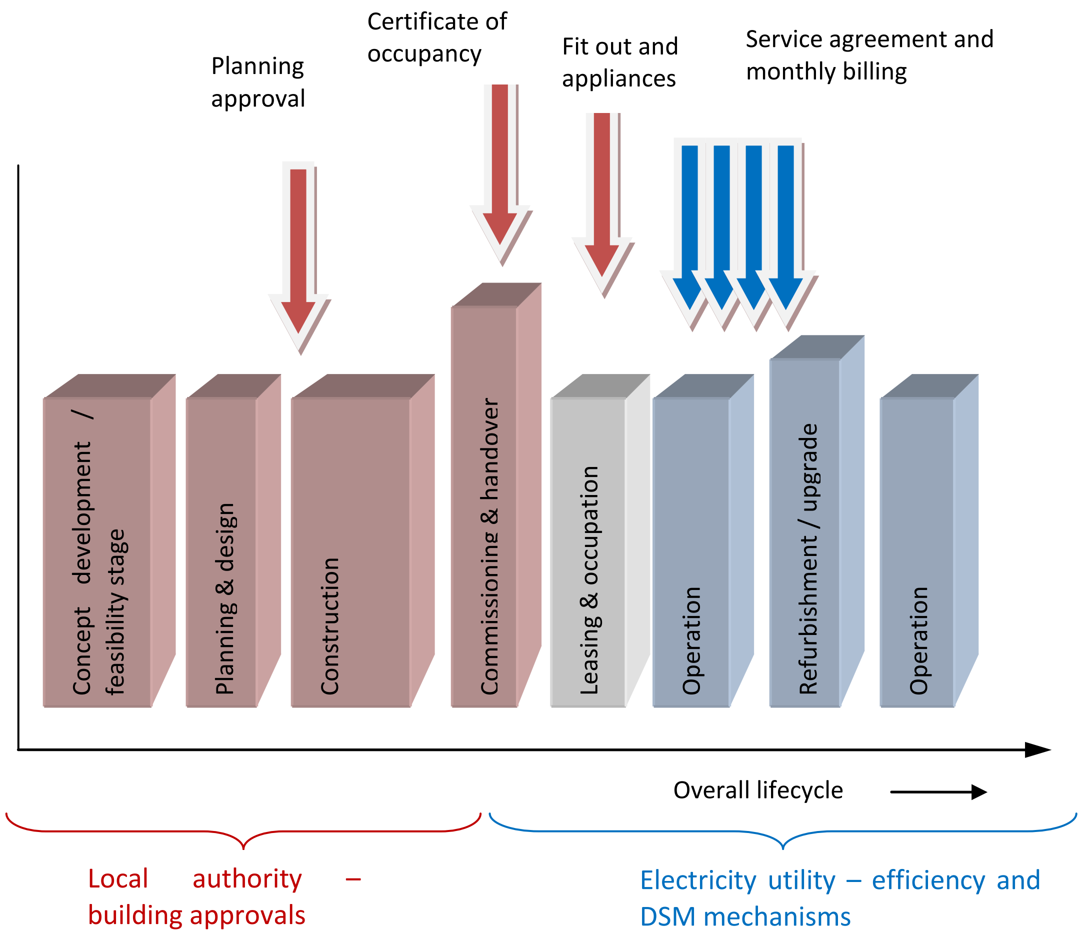


Figure 41 clearly shows that the role for energy efficiency standards for buildings is primarily in the concept development, design and planning approval phases (and subsequently in the refurbishment phases – if applicable) of the overall building lifecycle. On the other hand, the opportunities for energy efficiency in the operational phases of the lifecycle of a building are primarily of the DSM-type.

6.2 Experience with energy efficiency standards in Namibia

The demand-side management (DSM) study commissioned by the Electricity Control Board (ECB) in 2005 (and completed in 2006) has been the most significant recent initiative in Namibia to recommend the establishment of energy efficiency interventions which are applicable to buildings. There have been numerous projects undertaken over the years in Namibia which have researched or highlighted the opportunities for energy efficiency interventions in buildings but the DSM Study made specific recommendations including:

- Consumer education and awareness campaigns
- Time of use electricity tariffs
- Disseminating compact fluorescent lights (CFLs)
- Replacing electric water heaters with solar water heaters
- Expanding geyser ripple control systems, and

- Conducting energy audits in the commercial and industrial sector.

Subsequently, NamPower added demand market participation (DMP) to the above options. Since then NamPower, together with the ECB have started with the implementation of DMP and time-of-use electricity tariffs. NamPower also took the initiative of pre-financing the CFL campaign that was implemented jointly with the Ministry of Mines and Energy and the ECB. In addition the Ministry, ECB, NamPower and other ESI stakeholders started consumer education and awareness campaigns.
It is noted however that the cumulative impact that the DSM initiatives had on the energy use in buildings cannot be quantified to any degree, as pre-implementation baseline consumption data is unavailable.

6.3 International experience with energy efficiency standards

Internationally, energy efficiency standards to improve the energy performance of buildings have been developed over the past 40 years. The initial efforts in developing energy efficiency standards for buildings were prompted by the energy crises in the early 1970s.

Initially, these standards were based on prescriptive requirements, specifying materials and systems for more energy efficient buildings. Increasingly however, the trend is going towards performance based standards. The benefits of performance-based approaches are that these allow for (and encourage) innovation and flexibility in achieving the energy efficiency requirements in the standard. The key disadvantage of a performance-based approach is that these standards generally require methodologies and equipment for measuring, determining, reviewing and reporting the energy efficiency of a wide range of buildings. This is a complex and often costly requirement, which explains why it is often not implemented.

A review of regulations and policies for energy efficiency in buildings in different countries – including Australia, Singapore, Austria, Germany, Spain, and United Kingdom – highlighted the following common features (TERI University 2010):

- Separate regulations for residential and commercial buildings exist. In countries like Singapore, separate regulations for air conditioned and naturally ventilated buildings are in place.
- Separate regulations often exist for existing and new buildings.
- All countries have mandatory minimum standards on performance of the building envelope (walls, windows, roof) and glazing.
- All countries have mandatory minimum efficiencies recommended for lighting, daylight integration, HVAC and hot water systems.
- Some countries, such as the United Kingdom, have provisions to enable the energy efficient operation of a building, an example being the *Home Information Pack*.

The TERI University study concludes by highlighting the international best practices observed in Australia, Singapore, Austria, Germany, Spain, United Kingdom, with high-level best practice including the following:

- Hot water demand is to be met by solar energy.
- The design of the building should be able to meet the energy performance benchmarks developed for suitable climate zones, without compromising on human comfort.
- Compliance check with regulations is performed before and at the end of works.

- Metering of commercial buildings is mandatory.

A number of internationally recognised energy efficiency systems have been developed, such as:

- BRE Environmental Assessment Method (BREEAM) [UK][21]
- Leadership in Energy and Environmental Design (LEED) [USA][22]
- Green Star [Australia][23]
- SANS 204 national standard for energy efficiency in buildings [South Africa & Namibia]

BRE Environmental Assessment Method (BREEAM) is a voluntary measurement rating for green buildings that was established in the UK by the Building Research Establishment (BRE). Since its inception it has been adapted in various forms across the globe. Its equivalents in other regions include LEED in USA and Green Star in Australia, and HQE in France. BRE and CSTB (the French Building research centre) have signed a memorandum of understanding committing them to the alignment of BREEAM and HQE.

The Leadership in Energy and Environmental Design (LEED) is a green building certification system, intended to improve performance in areas such as energy savings, water efficiency, CO2 emissions reduction, improved indoor environmental quality, and stewardship of resources and sensitivity to their impacts. It was developed by the U.S. Green Building Council (USGBC). LEED is a design tool and not a performance measurement tool. It is not yet climate-specific, although the newest version hopes to address this weakness. Another complaint is that high certification costs require money that could be used to make the building in question more sustainable.

Based on the review of the international experience, the two most likely energy efficiency standards frameworks for consideration in Namibia are

iii. the SANS 204 / SANS 10400 national standard for energy efficiency in buildings and code of practice for building regulations in South Africa, and
iv. the voluntary GreenStar system for rating Green Buildings which is implemented in South Africa.

The South African energy efficiency standards frameworks are discussed in further detail in sections 6.4 and 6.5 below, while a selection of other international experiences with energy efficiency programs is further discussed in section 6.6.

6.4 SANS 204 – Energy efficiency in buildings

SANS 204 is South Africa's national standard for energy efficiency in buildings, published by the South African Bureau of Standards (http://www.sabs.co.za/).

SANS 204 is a performance-based standard, which sets out energy demand and consumption (in terms of electrical demand and consumption) for different categories of building occupancy and for different climatic zones. Provision is made in the standard for a motivation on the basis of a 'rational design', for cases in which the energy demand and

[21] Building Research Establishment UK, http://www.bre.co.uk/
[22] U.S. Green Building Council, http://www.usgbc.org/
[23] Green Building Council Australia, http://www.gbca.org.au/

energy consumption exceed the performance levels for specific combinations of occupancy and climatic zone. However, SANS 204 is not applicable for government subsidised housing.

SANS 204 provides a basis for code of practice for compliance with the National Building Regulations in South Africa[24], i.e. SANS 10400.

The current edition, Edition 1, was published in October 2008 and it comprises three parts, namely:

- Part 1: General requirements.
- Part 2: The application of the energy efficiency requirements for buildings with natural environmental control.
- Part 3: The application of the energy efficiency requirements for buildings with artificial ventilation or air conditioning.

Currently, the SANS 204 standard is under review.

6.4.1 Applicability of SANS 204 in Namibia

In the past, Namibia has adopted South African standards where such standards were viewed to be applicable and appropriate. This approach has the advantage of lower costs to the Namibian economy and more rapid development of a standards system, and also provides consistency and standardisation across the national borders within the SADC region. A further consideration in adoption of common standards between Namibia and its neighbours is the transferability of human resources within the region and the optimal utilisation of these human resources. It is therefore appropriate to consider the relevance and applicability of SANS 204 in Namibia.

Overall, the intention and approach in SANS 204 are consistent with those in the Namibian context. The key questions for applicability relate to the following considerations:

- Technical applicability
- Legal context and applicability
- Institutional context and applicability

6.4.1.1 Technical considerations

The main technical consideration in the applicability of SANS 204 in Namibia is the applicability of the climatic zones, which are defined geographically in SANS 204 in terms of the climatic characteristics of identifiable climatic zones in Namibia. Superficially, the Arid Interior and Temperate Interior climatic zones in SANS 204 which cover the Northern Cape Province and interior regions in South Africa may be similar and applicable to parts in Namibia, but these correlations will need to be investigated in more detail and determined in a systematic and rigorous manner.

This study identified survey sites in four distinct climatic zones in Namibia, namely the four major urban centres of Windhoek, Keetmanshoop, Walvis Bay / Swakopmund and Oshakati / Ongwediva / Ondangwa.

[24] National Building Regulations and Building Standards Act, 1977 (Act 103 of 1977) as amended.

6.4.1.2 Legal considerations

Namibian energy efficiency standards for buildings could be enforced in terms of the national building regulations, for example by local authorities responsible for planning approvals of building developments, as part of the planning approval stage of each individual project/building. The development and promulgation of such national building regulations could benefit from considerations and experience made in South Africa, but would necessarily be driven and tailored to the Namibian context by local stakeholders.

6.4.1.3 Institutional considerations

As indicated above, it is suggested that the local authority which is responsible for planning approval of new buildings also be responsible for approving the energy efficiency compliance of new buildings in terms of a national building regulation. Such approval processes would require new systems and processes in the relevant authorities, and be undertaken by staff who have had the necessary training in being able to verify compliance. These considerations illustrate one of the many practical challenges of introducing such national standards.

SANS 204 makes provision for municipalities to accept Energy Efficiency Certificates (or label such as an Energy Efficiency Passport) as issued by a 'competent person' as evidence of compliance with the standard. The standard also indicates that the local authority 'may' determine whether the issuing person is 'competent'. In Namibia, it may be feasible to have the local authority (municipality) fulfil the role of the authority requiring and accepting the energy efficiency compliance for individual buildings, but as noted above, such additional functions for local authorities require significant preparatory effort.

6.5 GreenStar SA rating system

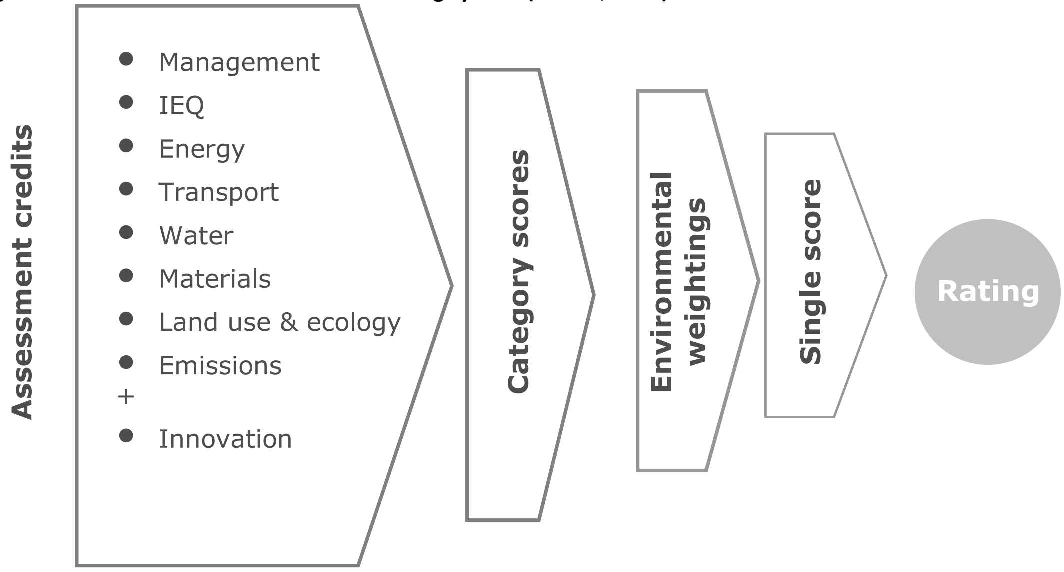
The GreenStar SA rating system is a holistic framework for assessing and rating the overall performance of buildings in terms of a comprehensive range of criteria, including energy performance. The rating system was developed in Australia by the Green Building Council of Australia (GBCA), and has been adapted (under licence) for application in South Africa by the Green Building Council of South Africa (GBCSA)[25]. Since its establishment in 2009, the GBCSA has developed three rating tools, i.e. for commercial buildings, retail centres and multi-unit residential projects, and is currently finalising a fourth one, i.e. for public buildings.

The GreenStar SA system is currently focussed on new buildings and does not apply to existing or retro-fitted buildings. It is intended to develop a rating tool for retro-fitted buildings based on the tool developed by the Australian GBCA.

Green Star SA establishes a number of categories under which specific key criteria are grouped and assessed. This framework is used by each and every Green Star SA rating tool. The basic Green Star SA structure is shown in Figure 42 below.

[25] The GBCSA is a national, not-for-profit organisation that is committed to developing an environmentally sustainable property industry for South Africa by encouraging the adoption of green building practices (http://www.gbcsa.org.za/).

Figure 42: Structure of the Green Star SA rating system (GBCSA, 2008)



The five criteria in the energy category in the GreenStar SA rating system include:

- Ene-1 Greenhouse Gas Emissions
- Ene-2 Energy Sub-metering
- Ene-3 Lighting Power Density
- Ene-4 Lighting Zoning
- Ene-5 Peak Energy Demand Reduction

6.5.1 Applicability of the GreenStar SA rating system in Namibia

The GreenStar SA rating system is currently licensed for use in South Africa, and is administered as a voluntary programme by the GBCSA. The GreenStar rating system could be applied in Namibia, but as yet, it would not be possible for building developers or owners to obtain a GreenStar rating for buildings outside of South Africa.

There is discussion among stakeholders in different African countries to establish Green Building Councils in such countries, but this may not be feasible in many countries due to the requirement for a critical mass of submissions and market participating to support a national system. It is speculated that Namibia does not currently enjoy sufficient market activity to support a comprehensive Green Building rating system.

6.6 Other International Experiences

6.6.1 Eskom's Demand-Side Management Programme

For over a decade, Eskom has implemented a demand-side management (DSM) programme in South Africa. This programme has focussed on demand reduction to mitigate the risks of load-shedding due to insufficient generation and transmission capacity, and has also allowed for efficiency interventions.

The DSM programme is structured as a performance contract implemented by registered ESCOs that are eligible for funding for capital investments in systems which yield demand reductions and efficiency gains. The programme is incentivised on the basis of a three way split of the financial benefits of savings on electricity, which are shared between Eskom, the ESCO and the customer.

The Eskom DSM programme does not target commercial buildings, but such buildings have nevertheless been included in the programme, mostly in the form of lighting retrofitting or air-conditioning plant upgrades.

There is no explicit link or institutionalised co-ordination between this utility-led programme and other stakeholders, such as local authorities or property owner associations.

6.6.2 Bangalore City Environmental Building Regulations and Guidelines

It is useful to consider case studies for energy efficiency in buildings based in other emerging and developing countries when assessing the potential and possible scope of implementing energy efficiency measures in Namibia.

The Indian City of Bangalore has developed Environmental Building Regulations and Guidelines, to “achieve energy efficiency in the city” (Teri University, 2009). In addition to eight guidelines for improved passive thermal design and integration of renewable energy systems[26], the document includes a ninth guideline which requires a mandatory energy audit for all existing commercial buildings with an electrical connection of greater than 500 kW or 600 kVA, and a requirement for an energy reduction of 20% compared to the previous year. The TERI study which underpins the guidelines recommended that mandatory energy audits should be enforced by the relevant electricity supply authority, as these could not be enforced by the local authority in terms of the building byelaws.

The guidelines suggest a rating scheme for buildings based on an energy performance index (EPI) for a given climatic zone. The EPI is calculated as the ratio of the total energy consumption per annum (electricity and fuel) and the effective floor area of the building (measured in kWh/ m^2/annum). For a temperate climatic zone, the EPI’s are ranked in terms of a rating as shown in Table 33.

Table 33 : Energy performance indices for buildings in Bangalore (TERI University, 2010)

Normalised EPI Bandwidth (kWh/m^2/annum)	Star Rating
400 – 350	1 star
350 – 300	2 star
300 – 250	3 star
250 – 200	4 star
Below 200	5 star

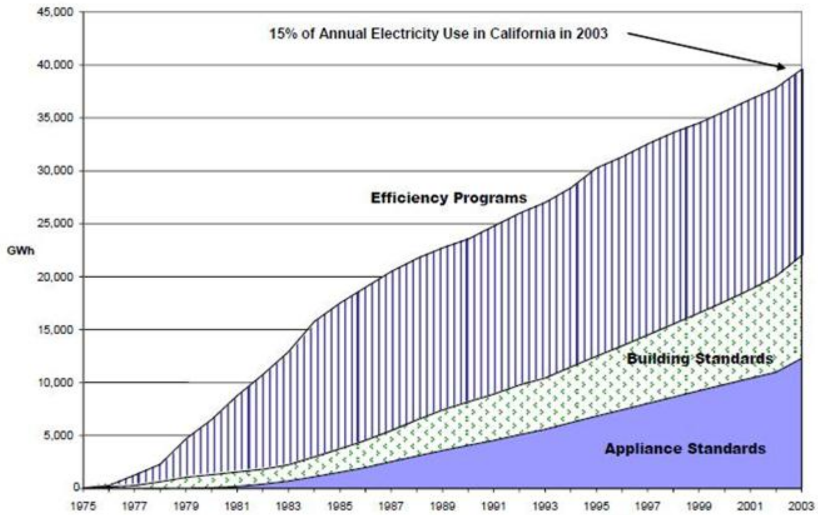
[26] Solar passive design; roof treatment to reduce heat gains; window treatment for lighting, ventilation and to manage heat gains / losses; energy efficient artificial lighting; energy efficient AC design; use of energy efficient appliances; SWH systems; energy efficient electrical distribution and switchgear.

6.6.3 Energy efficiency in existing buildings: CEC

Energy efficiency standards for insulation were introduced in California in 1975, and for whole buildings in 1977. These were followed by 'Second Generation Standards' in 1982.

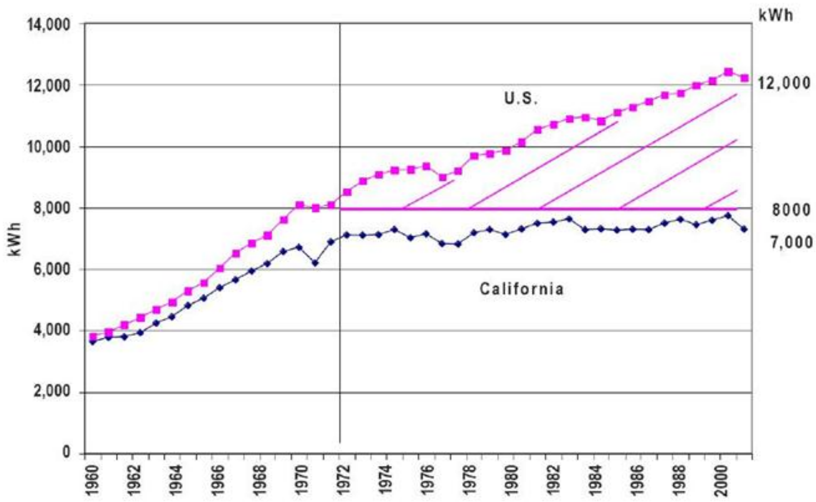
In 2005, the California Energy Commission (CEC) commissioned a report on energy efficiency in existing buildings. The report presents the energy savings achieved over 28 years in the existing building stock in terms of utility efficiency programmes, building standards and appliance standards, refer to Figure 43. It also documents the prevailing energy efficiency programmes in the state, and makes recommendations for improving the energy performance of the existing building stock.

Figure 43: Cumulative energy savings achieved by the California EE standards and programs (CEC, 2005)



The longer term trend of these energy efficiency programmes, in terms of specific energy consumption, is shown in Figure 44. It is clear that the active and focussed energy efficiency programmes in California have yielded dramatic relative success, especially when compared to the general electricity use in the rest of the USA.

Figure 44: Total electricity use per capita per year between 1960 - 2003 (CEC, 2005)



In December 2004, California established a Green Building Initiative (GBI) committing the State to a series of actions that will result in a 20% reduction in the energy use of state-owned buildings by 2015, and calls for a 20% reduction in the energy use of privately-owned commercial buildings.

In considering the opportunities for deepening the gains which had already been achieved until 2003, the study for existing buildings identified 'trigger points', which could offer opportunities to enforce or influence decisions related to energy efficiency. Examples of these 'trigger points' include:

- the sale of a property
- a change in the leasehold on a property
- the replacement of equipment and components installed on the premises, and
- refinancing, remodeling, renovation or rehabilitation events.

The effectiveness of these trigger point opportunities is increased by developing databases and diagnostic tools that assist in identifying the optimal interventions for energy efficiency improvements.

The key strategies for improving energy efficiency in existing buildings included:

6.6.3.1 Residential buildings

- **Time-of-sale information disclosure** – reporting of energy performance required for registration of house sales based on a 'Home Energy Rating System'. This intervention requires legislation.
- **Energy efficiency gateway** – an information portal (or resource centre) to provide awareness and information for homeowners. No additional legislation required.
- **Integrated Whole Building Diagnostic Testing and Repair** – a suite of diagnostic tools and the associated capacity to use these tools for assessments of existing buildings, including to systematically detect flaws in building construction or operation, diagnose their causes, and facilitate, enable and verify their correction, leading to energy savings as well as increased comfort, health, and safety benefits No additional legislation required.
- **Assistance to Affordable Housing** – policies and procedures to assist housing authorities to improve affordable housing stock. This intervention could be triggered by property upgrade programmes and would typically involve financing and tax rebate mechanisms. This intervention requires legislation.
- **Equipment tune-ups** – this is focussed on AC and heating systems and does not require additional legislation.

6.6.3.2 Commercial buildings

- **Benchmarking** – the CEC recommended to establish a benchmarking system within the context of the Green Building Initiative to enable buildings to be rated in terms of energy efficiency. The benchmarking is intended to provide energy consumption information in a form that commercial building owners and operators can use to compare their building's performance to similar buildings. Legislation is required to ensure that benchmarking is a requirement for sale or re-financing of a commercial building.
- **Retro-commissioning** – systematically investigates the operation of a building's energy consuming equipment to detect, diagnose, and correct faults in the installation and operation of commercial building energy systems. This would be a

voluntary programme but could also be triggered by a sale or re-financing event. No legislative action is needed.

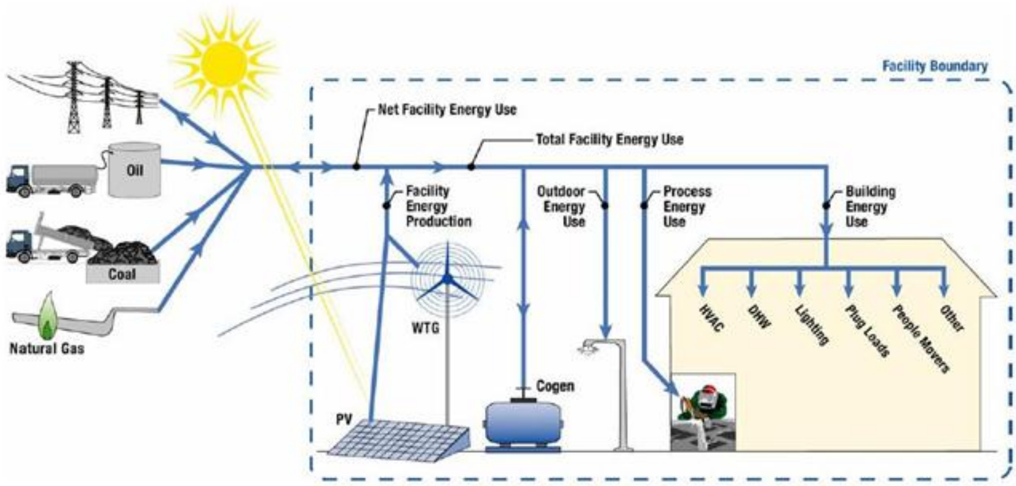
The CEC report highlights the need for close co-operation with the energy utilities to support an energy efficiency programme for existing buildings.

6.6.4 NREL procedure for measuring and reporting energy performance

The National Renewable Energy Laboratory (NREL) in the USA investigated procedures for measuring and reporting energy performance in buildings (Barley D, 2005).

The NREL procedure is intended to provide a standard method for measuring and characterizing the energy performance of commercial buildings. The procedure determines the energy consumption, electrical energy demand, and on-site energy production in existing commercial buildings of all types. The performance metrics from the procedure may be compared against benchmarks to evaluate performance and verify that performance targets have been achieved. The procedure considers the energy flows in a building, as shown in Figure 45.

Figure 45: Typical energy system and energy flows for a building



Uses of the outcomes of the procedure may include:

- Comparisons of actual performance against the design intent
- Comparisons of actual performance with other same buildings
- Evaluation of building performance rating systems
- Economic analyses of energy-efficient strategies in buildings
- Establishing long-term performance records that enable maintenance staff to monitor trends in energy performance.

The NREL procedure is defined in two tiers, to differentiate the resolution of the results and the amount of effort typically required to complete the procedure. Tier 1 gives monthly and annual results for the facility as a whole, based primarily on utility meter readings. Tier 2 yields time-series results (typically 15- or 60-min data, which should correspond to the electrical demand billing scheme, if applicable), in addition to monthly and annual results, itemized by type of end use, based on sub-metering and a data acquisition system.

The NREL procedure is a measurement procedure, and does not identify or prioritise energy efficiency interventions.

6.7 Lessons learned from compliance standards / programmes

A UNDP GEF review of energy efficiency in buildings (UNDP, 2009) systematically reviewed different public policy interventions including:

- Regulations
  - Energy building codes
  - Building component and equipment standards
  - Utility-based energy efficiency targets, including DSM programmes

- Information
  - General awareness and information campaigns
  - Audits and energy use reports
  - Building certificates and labels
  - Labelling of construction products and equipment
  - Local energy efficiency information centres: Providing practical individualised information and technical assistance
  - Training
  - Demonstration programmes
  - Research and development

- Financial incentives
  - Energy prices
  - Rebates, subsidies, grants (including DSM programmes
  - Tax incentives / energy taxes
  - Low-interest loans and guarantee funds
  - ESCOs / performance contracting
  - Carbon Finance

- Public authorities and public buildings – showing the way

The UNDP study concluded with the following important statement:
The most widely used and effective policy orientations, when they are pursued in a thorough and adequate way, include implementing mandatory prescriptions such as Energy Building Codes, enrolling proactive structures to 'market' energy efficiency directly to consumers, and working with municipalities. The best results are reached when these instruments are combined with other information or financial activities in policy packages (UNDP, 2009).

A recent study reviewed state energy code compliance and enforcement efforts in the USA (Misuriello, 2010). Amongst others, the study aimed to develop recommendations for focused code enforcement to meet Federal code compliance performance goals. The preliminary findings revealed the following common issues:

- The as-built buildings often differ from the original approved building plans and, furthermore, incorporate non-compliant equipment (in terms of energy efficiency) which has been substituted for the originally specified equipment in the approved plans.
- Training and capacity building for compliance and enforcement of energy efficiency regulations is required.
- Most compliance studies are once-off exercises that use ad-hoc or project specific methodologies and reporting formats. Consequently, it is difficult to make comparisons or establish benchmarks for energy efficiency in buildings due to the lack of uniformity or consistency in the studies.
- A proposed US DoE methodology and standard methods for collecting, analysing, and reporting data is expected to improve the quality and uniformity of energy efficiency studies and, in turn, to facilitate the comparison.

7 Conclusions

7.1 Energy Benchmarking of Namibian Buildings

- Building improvement data is not comprehensively captured and not readily available from all local authorities. This data gap implies that a detailed assessment of current building energy use is complicated and would often necessitate an energy audit (which was beyond the scope of this study).

- The study does not show climatic influences on electricity use and maximum demand benchmarking figures, due to the small sample and largely different operations within the same class of buildings being surveyed.

- Average energy consumption benchmarks show that large shops (supermarkets) are the most energy intensive, followed by hotels, then office buildings.

- Urban areas comprise mainly residential land. Domestic electricity consumption is of the order of 40% of total urban consumption.

- The SANS 204 standard does not include Namibia in the list of climatic zones, which will make its implementation more problematic.

- Comparison of average energy consumption benchmarks as determined in this study and SANS 204-1 shows little correlation other than for offices. A significant discrepancy between the SANS 204 values for large shops and hotels, and the values obtained in this study, is apparent.

Table 34: Comparison of average demand benchmark vs. SANS 204

Building classification	Energy benchmark kWh/m²/annum	
	Survey Energy Benchmark Average	Average SANS 204 specified maximum
Supermarkets (large shop)	806	246
Warehouse shops (large shop)	103	246
Offices	189	196
Hotel	153	609

- A comparison of similar buildings with high and low benchmark values indicates that there is substantial scope for energy efficiency improvements in less efficient buildings, with supermarkets 40% less than highest benchmark supermarket, offices 59% less than highest, and hotels 35% less than highest.

- Most buildings surveyed (66%) are owner occupied, while hotels are 40% tenanted.

- Tenants are usually responsible for payment of electricity (82%).

- Renting can be a barrier to undertaking energy efficiency improvements in cases where fixed asset capital investments are necessary.

- There is little correlation between the demand average benchmarks determined in this study and SANS 204.

Table 35: Comparison of average demand benchmark vs. SANS 204

Building classification	VA/m²	
	Survey Demand Benchmark Average	Average SANS 204 specified maximum
Supermarkets (large shop)	110	89
Offices	27	79
Hotel	51	89

- About one-half of all building occupants surveyed (55%) intend to renovate and/or move within the next 2 years.

- Only 20% of the survey respondents are of the opinion that their building is energy inefficient.

- There is a demand for clear information regarding appliance efficiency. Many respondents indicate that they are eager to make more informed choices, but lack access to clear information. The research and dissemination of such information is best done centrally.

- It is easier to achieve efficiency savings in commercial buildings than it would be with domestic energy efficiency.

- Benchmarking of domestic energy consumption for Namibia is necessary, and is expected to yield considerable savings potentials if energy efficiency measures are introduced.

- Reliable climatic data to aid building design is not readily available for Namibia.

7.2 Energy Efficiency Standards

- Namibia's building design process often proceeds without an evaluation of the building's thermal performance. This disconnect between the design process and associated long-term energy costs continues to deliver sub-optimal building stock.

- Many towns and villages in Namibia do not have the institutional capacity to carry out the building approval process as rigorously as they are done in the capital city. The introduction of energy efficiency standards would therefore not only require changes in local authority legislation, but necessitate that training is offered to ensure consistent implementation. These aspects constitute considerable barriers which require additional analysis.

- Public buildings in Namibia are not subject to the municipal building approval process. This creates an opportunity for the implementation and application of building standards in the public sector, such as SANS 204, as the Department of Works in the Ministry of Works, Transport and Communication could decide to require that all new buildings above a certain size comply with such a standard. The introduction of energy efficiency standards could yield substantial long-term benefits to government, and by implication, the tax-paying public. In analogy to the Cabinet resolution making it obligatory for all new and renovated government facilities to use SWH, other energy-related building standards could be introduced step-wise in government buildings exceeding certain minimum floor areas.

- In most parts of Namibia (Windhoek is an exception) the electricity supply is no longer the responsibility of the local authority and has been taken over by a Regional Electricity Distributor (RED). This implies that local authorities now have even less interest in ensuring that electricity is used efficiently (for example by ensuring that distribution networks are optimally sized and that exeedances of the declared maximum demand can be minimised), while the revenues of REDs are almost directly proportional to their electricity sales. This split in responsibilities reduces the incentive to champion the introduction of energy efficiency standards.

- The introduction of national energy efficiency standards requires a national champion. While the Ministry of Mines and Energy is the custodian of Namibia's energy-related policies, it is unlikely to have or wish to develop the necessary human resources and infrastructure to oversee the national roll-out and application of energy efficiency standards in buildings. This raises the question which institution / entity would be the most natural champion for energy efficiency in Namibia. The Electricity Control Board could develop such capacity, but would require considerable additional regulatory, legal and statutory powers to allow it to ensure their implementation. It is clear that an institutional owner for the implementation and oversight of energy efficiency in Namibia does not yet exist, and will require considerable additional human resource, policy, legal, regulatory, technical and financial preparations.

- International experience shows that market forces are often insufficient to effect the required changes quickly enough, even with benchmarking and standards in place. In most cases, a legislative and/or regulatory intervention is required to ensure compliance and the desired outcomes.

- A well-designed and consistently implemented national energy efficiency programme, based on a progression of measures rolled out as part of an overall, ongoing, long-term programme to introduce energy efficiency in the country's building stock is likely to yield the best long-term results. Such measures should include
  - Equipment, appliance and building standards
  - Energy efficiency standards
  - National energy and energy efficiency targets
  - Appliance labelling
  - Support of voluntary efficiency programmes and initiatives
  - Taxation and subsidies

  - Audits and assessments, possibly with some direct support
  - Research and development
  - Voluntary (and in time compulsory) reporting the energy and CO_2 intensity of commerce and industry, possibly as part of a carbon disclosure project
  - Information dissemination

- Energy-related life-of-building costs are often not available.

- Energy-related operating costs are often neglected by both owners and tenants.

- Financial institutions are often unaware of the considerable long-term benefits of having client's introduce energy efficiency measures. A focus on capital expenditures often ignores cost savings from reduced operating and maintenance costs.

- The formulation and introduction of national standards requires sensitivity and circumspection, to ensure that they do not only benefit a few high-intensity users (e.g. supermarkets).

- Architect and designers are at the touch point between prospective building developers and the application/introduction of energy efficiency measures in new buildings, and as part of a building refurbishment process. In the absence of a targeted awareness program, out-dated designs are perpetuated and continue to deliver sub-optimal building performances.

8 Recommendations

These recommendations are made based on the findings of this study and previous international experience. The recommendations are grouped according to the following different components:

a) Regulation measures
b) Information dissemination and awareness creation
c) Financial incentives
d) Public buildings – showing the way

Regulation measures

1. If an energy benchmarking system is to be applied in Namibia, SANS 204 (which in theory is applicable in Namibia) is considered the most likely candidate. However, SANS 204 requires review to enhance its relevance for Namibia, in particular:
    a. the classification of buildings (particularly commercial)
    b. benchmark maximum values for classifications
    c. addition of climatic zone information for Namibia
    d. the introduction of minimum threshold floor areas for classifications.

2. Namibia should preferably become part of the review of SANS 204 with the SABS, through the Namibian Standards Institution.

3. Energy performance simulation of new building stock and building refurbishments is an effective way to ensure that energy use in buildings is quantified before the construction or refurbishment of such buildings. Such performance assessments are especially useful for buildings where the building envelope is a critical determinant of the building's long-term energy consumption (including larger offices, hotels and any other non-residential buildings). An assessment of the costs and benefits of making such performance assessments obligatory – at the building approval stage – should be made.

4. Using a building energy model as an integral part of a building's approval process would assign the responsibility for the building's ongoing energy performance to a tangible entity such as the owner, who may for example sub-contract a consulting engineering firm. In this way, once an energy certificate is issued upon completion of a building, the owner will certify and remain responsible for the building's ongoing energy performance. This would enable the building's owner, or supply authority / local authority, to address a building's non-performance (similarly to the process applied to certify the structural integrity of buildings). An assessment of the requirements, costs and benefits of making such performance assessments obligatory should be made.

5. An assessment of the benefits of a programme establishing maximum demand benchmarks for REDs should be undertaken. This could entail establishing maximum demand targets for different (mostly commercial and industrial) consumer classes within a supply authority's territory, which could be based (amongst others) on a particular client's building type and an electricity consumption plan. If such a client remains within their declared energy consumption and maximum demand, they would be charged standard consumption and demand charges. In case a client exceeds their stipulated energy consumption and/or maximum demand for their

class of building, they would have to pay a premium for such excesses. This would incentivise the introduction of energy planning for commercial and industrial properties and lead to an increased plan-ability of network, infrastructure and capacity upgrades for REDs, in addition to providing improved energy use forecasts.

Information dissemination and awareness creation

6. Awareness raising programmes should be undertaken to disseminate information on energy efficiency, energy efficient appliances, the results of this study and the results of other energy efficiency interventions to sensitise the broader building market to the economic benefits of energy efficiency and the cost of inefficiency.

7. Energy benchmarking activities should be continued to allow energy benchmarking standards to be established for other building classifications, and to expand the database of existing buildings.

8. Energy audits of the top 10 (agreeable) buildings identified should be conducted for demonstration and practical purposes, as substantial scope for savings exist. It is furthermore recommended that
    a. energy efficiency conversions should be undertaken where viable, and
    b. building owners who agree to an energy audit should also undertake to agree to a reasonable set of interventions.

9. Case studies summarising the approach, findings and lessons of Namibian energy audits in buildings should be made public, and include a cost-benefit analysis of all interventions made.

10. Attention should be given to tenanted buildings in the demonstration energy audit process to ascertain the significance of the owner/tenant considerations in regard to improvement of energy efficiency. If this is identified as a barrier, then an investigation of mitigating measures should be undertaken.

11. A domestic energy consumption benchmarking exercise should be undertaken.

12. The energy efficiency of typical appliances and processes (e.g. cooking, baking, laundry, IT equipment) should be investigated with a view to providing the market with clear and relevant energy efficiency information applicable in Namibia.

13. The potential value addition of introducing alternative energy sources for typical processes including cooking, baking, laundry and others should be investigated to provide the market with relevant cost-benefit information applicable in Namibia.

14. Local authorities should apply the same set of principles for their respective town planning and development for zoning processes.

15. The benefits of a programme of voluntary self-regulation in regard to applied energy efficiency in buildings should be assessed. Such a programme could be rolled out to initially create the required processes and structures for Government buildings. Once the Department of Works is seen to apply self-regulation in their own building

stock, those private sector participants who have not introduced their own energy efficiency upgrades may follow more easily.

16. A platform for the regular exchange of ideas and/or competitions for architects, designers and engineers should be initiated, incentivising innovation in energy efficiency, and paving the way for a voluntary adoption of energy efficiency standards and the introduction of green building performance indicators in Namibia.

17. Climatic data for most major Namibian urban centres should be made available to provide building designers with a common resource to allow for analysis and design of new buildings. This process should be initiated and promoted as part of the NEEP project, in close collaboration with the Namibia Meteorological Service.

Financial incentives

18. In general, economic incentives automatically flow from energy efficiency measures. However, awareness creation and information dissemination activities are required to highlight the financial benefits of energy audits and the application of energy efficiency measures in buildings. Information about the financial implications of energy efficiency upgrades would further encourage voluntary energy audits and implementation of energy saving measures.

19. Where economic forces alone do not promote energy efficiency, targeted financial incentives should be considered. Countries promoting the private uptake of, for example, renewable energy generation have successfully implemented financial incentives to achieve this objective. A comprehensive macro-economic assessment should be undertaken to determine which energy efficiency and renewable energy technologies will benefit Namibia macro-economically (for example, in terms of job creation, enhanced energy security and mitigation of long-term finance risk). In addition, an assessment of the cost and impact that financial incentives in their various forms would have on the application of energy efficiency measures should be undertaken..

Public buildings – showing the way

20. The Department of Works (DOW), as custodian of all public buildings in Namibia, should be supported to embark on the evaluation and energy efficiency conversion of their own stock of buildings.

21. DOW should require of consultants designing new public buildings that energy efficiency considerations are included, and in this way become an integral part of the public building approval process.

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Appendix 1 Selection of building classification

The building occupancies selected for this study is based upon building regulations (SANS 10400). The rationale follows from the NEEP project objectives, and the criteria used is as follows:

a) There should be a reasonable stock of such buildings within Namibia.
b) Expectation of good potential for energy savings for that category.
c) Good expectation that data is readily available for the building category.
d) The individual type of buildings should be reasonably similar and comparable.

So, for example:

- There are few Museums (C2) in Namibia and these are excluded due to criteria (a).
- Parking Garages (J4) exhibit very low energy consumption and are excluded due to criteria (b)
- Dormitories (H2) are generally reasonably high energy consumers due to related kitchen and water heating energy requirements. However, unfortunately dormitories (or hostels) are typically included together with schools, classified as “Places of instruction” (A3), and there is not separate energy consumption data for dormitories independent of schools. Thus applying criteria (c), dormitories are excluded.
- Industrial buildings (D1, D2, D3) provide for a variety of industry which have varying energy intense activities. This makes it difficult to compare energy consumption between industries and industrial activity is thus excluded due to criteria (d).

The list of different building occupancies according to SANS 10400 is indicated in the table below, together with the rationale for exclusion of certain occupancies to reduce the sample size in order to satisfy the project timeframe and cost criteria.

Table 36: Building Classifications per SANS 10400

Classification of occupancy of buildings				
Classification of occupancy of buildings	Description of building	Disqualifying Criteria	Benchmark Included	Reason for inclusion/exclusion
A1	Entertainment and public assembly	a	No	Few facilities
A2	Theatrical and indoor sport	a	No	Few facilities
A3	Places of instruction	B	No	Low energy consumers
A4	Worship	a, b	No	Few facilities, low energy
A5	Outdoor sport	a, b	No	Few facilities, low energy
B1	High-risk commercial building	d	No	Difficult to compare
B2	Moderate risk commercial service			
B3	Low-risk commercial service			
C1	Exhibition hall	a, b	No	Few facilities, low energy
C2	Museum	a, b	No	Few facilities, low energy
D1	High-risk industrial	d	No	Wide variety of industry processes makes comparison difficult
D2	Moderate risk industrial			
D3	Low-risk industrial			
D4	Plant room	c, d	No	Wide variety of processes
E1	Place of detention	a, b	No	Few facilities, reasonable energy consumers
E2	Hospital	d	No	Variety of facility types
E3	Other institutional (residential)	a	No	Few facilities
E4	Health care	d	No	Variety of facility types
F1	Large shop		Yes	Significant energy use, good savings opportunities
F2	Small shop	d	No	Variety of facility types
F3	Wholesalers' store	b	No	Low energy consumers
G1	Offices		Yes	Significant energy use
H1	Hotel		Yes	Significant energy use
H2	Dormitory	c	No	Significant energy use, lack of individually metered electrical energy consumption data
H3	Domestic residence	c, d	No	Complex analysis required
H4	Dwelling house			
H5	Hospitality	a, d	No	Few facilities
J1	High-risk storage	b	No	Low energy consumers
J2	Moderate risk storage			
J3	Low-risk storage			
J4	Parking garage	b	No	Low energy consumers

Thus it was proposed that only 3 occupancies, highlighted in grey, would be benchmarked. These building types are comparable, are common across Namibia, generally have good potential for achieving energy savings, and are expected to have data available for benchmarking.

Appendix 2 Building tenant/owner survey questions

Tenant Survey Questions
(Building occupant, preferably management person responsible for energy accounts)

1) Name of person interviewed:
2) Organisation:
3) Contact telephone number:
4) Does the owner or tenant pay the electricity account?
5) Does the owner or tenant pay the other energy accounts (gas, diesel, paraffin)?
6) Who is your electricity supplier?
7) Do you understand your electricity tariffs? (Yes/No)
8) What tariff is being applied to this facility? (Don't coach person)
9) Do you use any energy management systems or methods? (Yes/No)
10) If yes, describe energy management methods:
11) What is your largest energy cost?
12) Do you consider energy efficiency when buying appliances/equipment? (Yes/No)
13) If Yes, Do you have an example? OR Comment:
14) If No, would you consider purchasing EE equipment if you had clear information?
15) How long have you occupied this building? (years <100)
16) Approximately when will you renovate/expand/move? (years <10)
17) Are you planning new equipment purchases? (Yes/No)
18) If yes, what type of equipment?
19) Have you heard of energy audits? (Yes/No)
20) If Yes, have you commissioned an energy audit? (Yes/No)
21) If Yes, have you implemented any energy efficiency measures? (Yes/No)
22) If Yes, what energy efficiency measures have been implemented?
23) Do you believe that energy efficiency would lower your energy costs? (Yes/No)
24) If Yes, By how much percent do you think that EE would lower your energy costs? (%)
25) If No, why not? (Or Comment:)
26) How much energy cost (dollar) savings percentage would make you want to change? (%)
27) Would you (your organisation) pay a higher rent for a lower energy cost? (Yes/No)
28) Comment:
29) Would you (your organisation) pay a higher rent for a "green" building, irrespective of cost savings? (Y/N)

Building Owner Survey Questions

1) Name of owner (owner's representative):
2) Organisation:
3) Contact telephone number:
4) How many years have you owned the building?:
5) When was the building first constructed?:
6) Are you considering renovation in the next 10 years? (Yes/No)
7) If Yes, when (in years <10)?
8) How energy efficient do you consider the building?
9) Do you believe that improved energy efficiency would be to your benefit as owner? (Yes/No)
10) If yes, indicate why?

Appendix 3 Building survey data