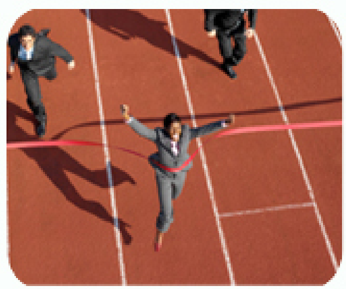
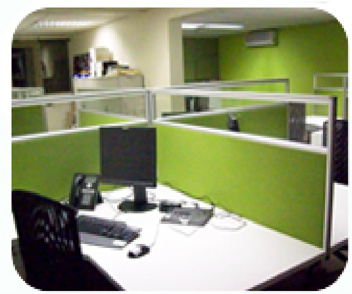
SANAP

Energy Efficiency, Emissions Pollution & Renewable Energy Improvement Initiative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20 YEARS OF FREEDOM
south africa 1994 - 2014

International Responsibilities

SANAE IV (South Africa's current Antarctic station) is located at:
- 70° 40' 25" South and 2° 49' 44" West, and approx. 4 500 km from Cape Town

All countries managing stations in the Antarctic do so in line with:
- the **Antarctic Treaty** (1959)
    - *SA is one of the 12 original signatories,* and
- the **Madrid Protocol** (1991)
    - *for environmental protection and sustainability responsibilities*

As an Antarctic Treaty Consultative Party **(ATCP),** SA is also a member of:
- the Council of Managers of National Antarctic Programmes **(COMNAP)**
- the Committee for Environmental Protection **(CEP),** and
- the Scientific Committee on Antarctic Research **(SCAR)**

SA also manages a research station on **Marion Island** (Southern Ocean), and a weather station on the UK's **Gough Island** (South Atlantic)

SANAP & NRF Mandate

The South African Antarctic and Southern Ocean Research Plan (2014 – 2024)

Research Theme 4: Innovation: *Southern Ocean and Antarctic technology and engineering*

Because of the extreme environment in Antarctica and the Southern Ocean (including the islands), there is a constant need for the maintenance, improvement and re-design of equipment, infrastructure the supporting management systems that underpin research

(i) Construction
The harsh conditions in the Southern Ocean, her Islands and in Antarctica give researchers the opportunity to investigate and evaluate new construction methods, materials and techniques. These conditions require innovative solutions. Such issues as **energy efficiency**, skill requirements for implementation and maintenance, and ease of transportation are especially important in the region.

(ii) Communications
Much of the research in the region generates large volumes of data that need to be communicated, often in real time, from relatively remote locations. Such communication is required from the transport vessels, from the permanent bases, and from various temporary research points. The central management of such research data, as well as access to the same, is an important consideration.

(iii) Energy management and generation
The smooth and efficient running of research operations in the region requires a significant energy input. **Clean energy alternatives** should be developed and tested under the region's extreme conditions. Such alternatives would substantially reduce the costs and **environmental impacts of current non-renewable energy usage**.

(iv) Infrastructure design, research and evaluation
South African researchers have access to significant research infrastructure, both on the SA Agulhas II, and at the permanent research bases. This sets the stage for continued research and development through equipment and infrastructure testing and evaluation. As an example, ongoing condition monitoring of research vessels, research bases and equipment will ensure a better understanding of equipment performance in extreme conditions.

(v) Robotic platforms
The remoteness, as well as the extreme environmental conditions experienced in the Southern Ocean and Antarctica, limits human access for extended periods of time. Robotic platforms not only save considerable resources and make the working environment safer for scientists; but also spur advanced skills development and job creation in South Africa.

(vi) Supplies management and materials handling
Material handling and supply management forms an important area of operations at the various research bases in the region. Research on, and evaluation of existing systems can be used to improve general operations, both at the bases and back in South Africa.

(vii) Waste management
Waste generated as the bases in the Southern Ocean and on Antarctica is kept isolated from the general environment for extended periods of time. The development of systems that reduce waste, or provide for alternative uses for waste, thus **saving energy** and resources, is important for the region.

(viii) Security of infrastructure and natural resources
The remoteness of the sub-Antarctic islands put these at risk, both in terms of the infrastructure and in terms of the surrounding natural resources. By developing effective remote monitoring programmes for the sensitive marine resources as well as regional infrastructure, potential threats to human life or marine resources can be evaluated and protected appropriately.

(ix) Research platform design:

There is clear potential for research platform innovation and design technology. High foreign exchange costs would **promote local development.**

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Electricity Generation Cost

2017	SANAE IV		Marion		Gough		TOTAL	
Consumption	(Liters)	(kWh)	(Liters)	(kWh)	(Liters)	(kWh)	(Liters)	(kWh)
	338920	1197265	239162	456315	64314	128628	642396	1782208
Cost	R 4 138 213.20		R 2 920 168.02		R 785 273.94		R 7 843 655.16	

- Fuel cost indicated **excludes** logistics and transport costs from Cape Town to the bases

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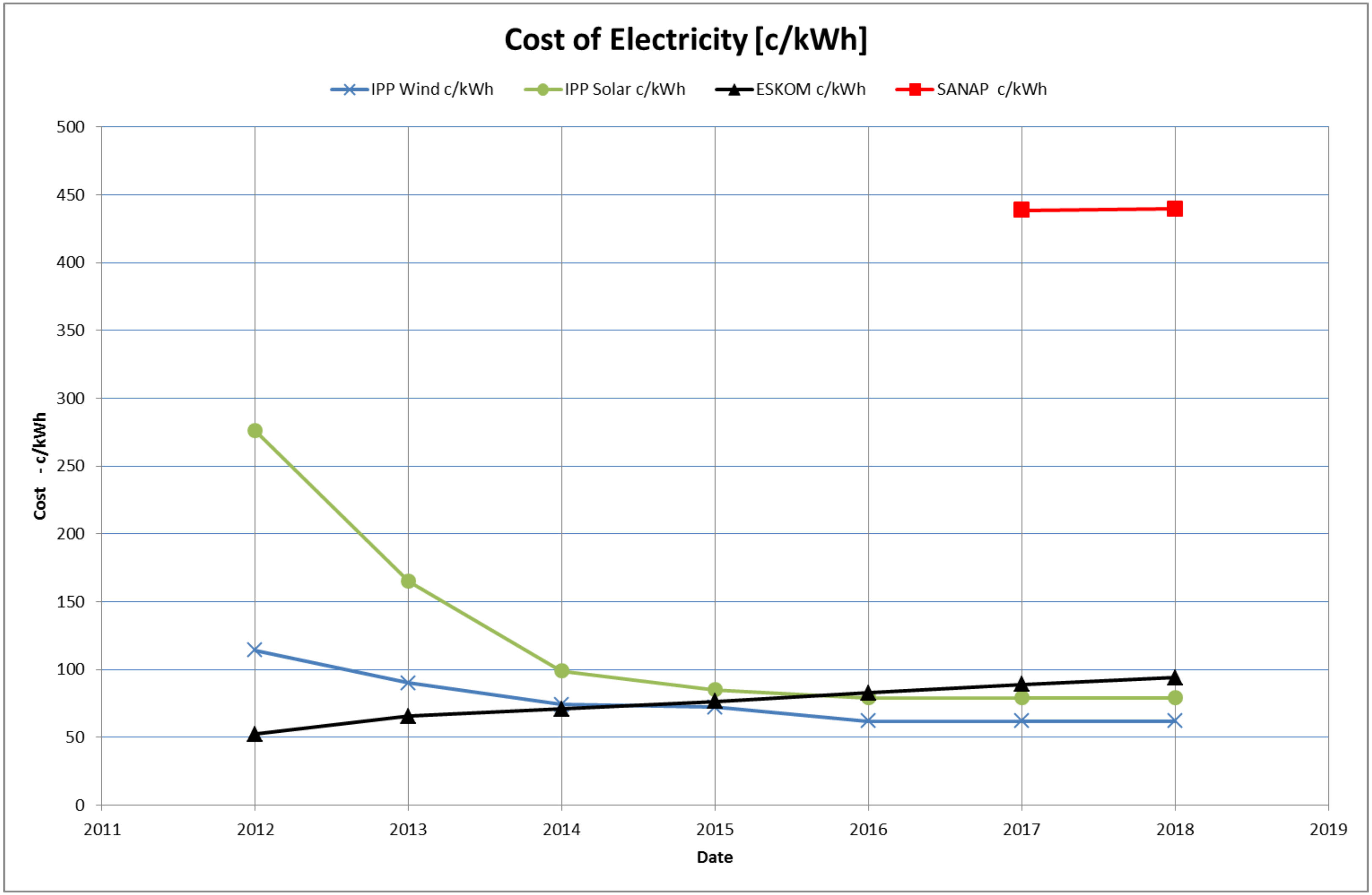
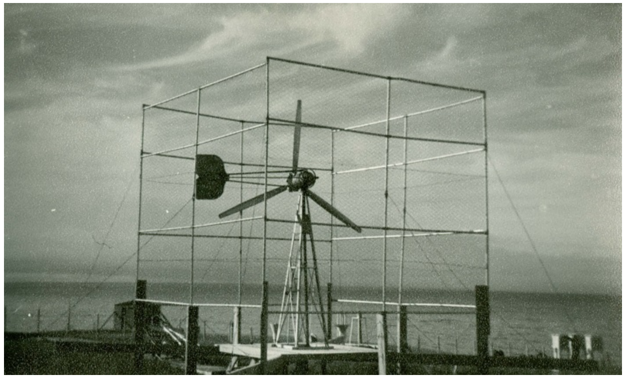
SANAP Electricity Cost vs IPP and ESKOM



Historic - Renewable Energy Wind Projects

Small Wind Turbine Investigation for SANAE IV
- Stellenbosch University (2007/08 to 2011/12)

- Programme initiated by Dept. Electrical and Electronic Engineering (funded by NRF and SANAP)
- **Aim:** To promote engineering research, to develop and to implement wind energy conversion technologies at SANAE IV and in SA
- During the 5-year period **1 PhD** and **7 MSc students** completed their studies on engineering aspects of this project
- In addition, 17 national and international publications in this field have been published
- The Wind turbines tested at SANAE IV were designed and manufactured in SA



Wind Energy Potential of Vesleskarvet and the feasibility of meeting SANAE IV's energy demand - Elsevier (2015)

Technical and Economic Evaluation of the Utilisation of Wind Energy at the SANAE IV Base in Antarctica
University of Stellenbosch (2002)

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Historic - Renewable Energy Solar Projects

MARION ISLAND SOLAR ENERGY PROJECT

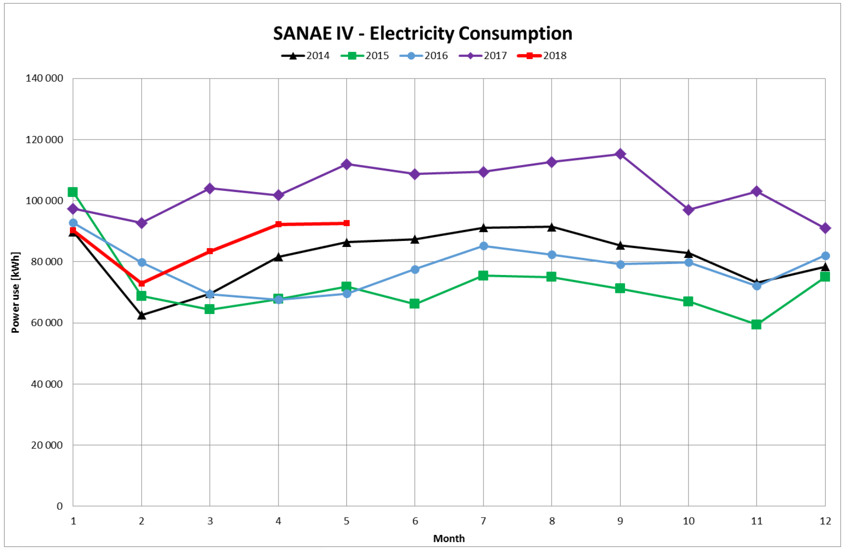
- Solar panels are used to charge 12V lead acid batteries to power the HF radio communication network at most of the 9 field huts on the island

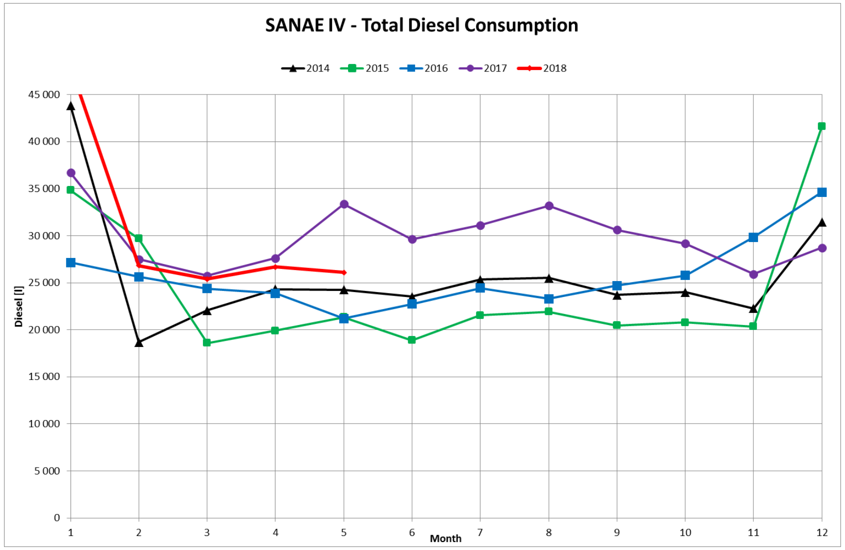
TECHNICAL AND ECONOMIC EVALUATION OF THE UTILISATION OF SOLAR ENERGY AT SANAE IV - Stellenbosch University [MScEng] (2005)

Deployment of ICEPAC solar- and wind-powered mobile IPY art and science research station, Antarctica (2009) * *Project supported by SANAP and SANERI*

Historic - Energy Efficiency Projects

- **Investigate Reducing the Impact of Diesel Engines on the Antarctic Environment and Associated Maintenance Benefits -** Stellenbosch University (2002)
- **Mitigating SNOWDRIFT at the elevated SANAE IV research station in Antarctica: CFD simulation and field application -** Stellenbosch University (2009)
- **Heating and Ventilation System Analysis and Redesign of the SANAE IV Base in Antarctica -** Stellenbosch University (2000)
- **Energy Audit of the Heating and Ventilation System of the SANAE** Stellenbosch University (2002)





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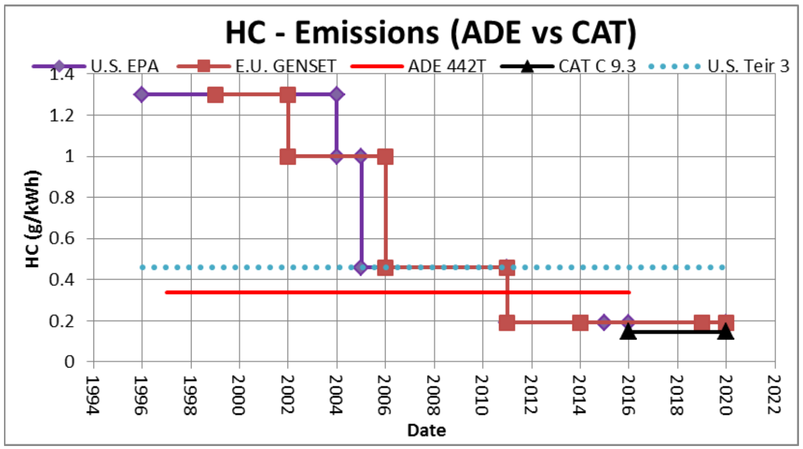
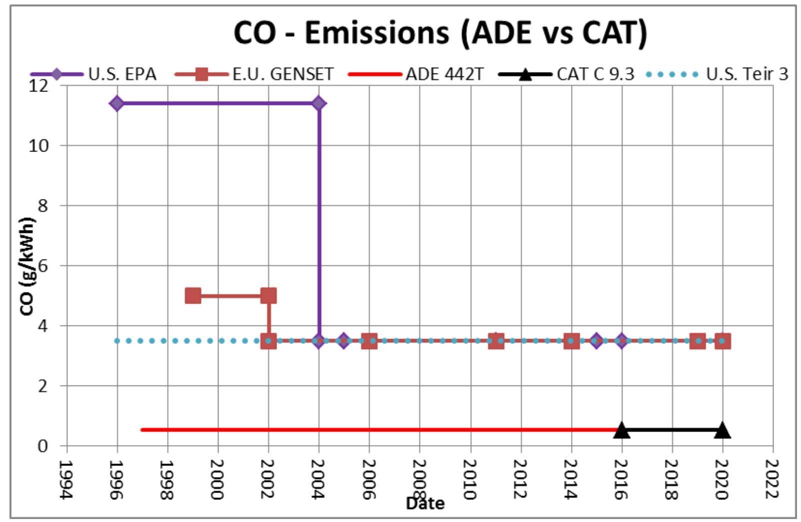
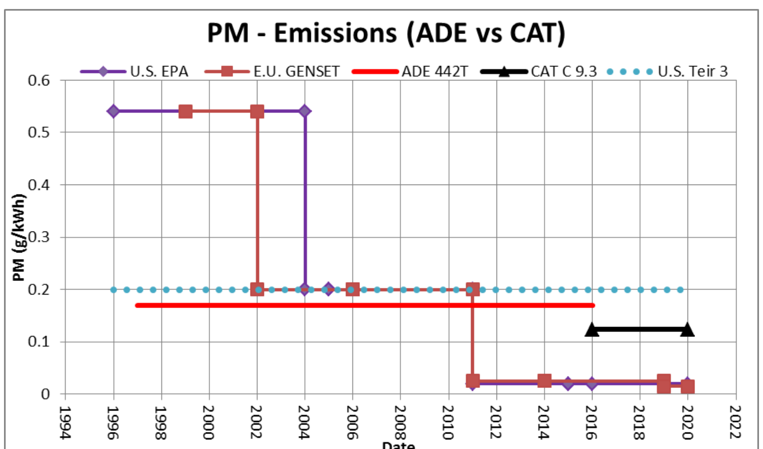
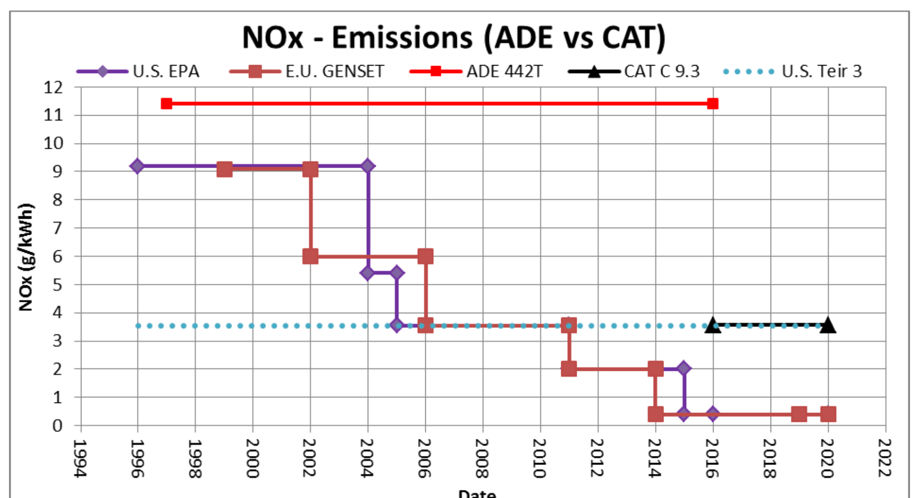
Historic - Exhaust Emissions Investigation

The 3 x old ADE 442T generators at SANAE IV were replaced with 3 x CAT C9.3 generators during 2016/2017 relief voyage (NDPW)
Exhaust emissions of the new CAT C9.3 generators are U.S. EPA Teir3 and E.U. Non-Road Mobile Machinery (NRMM) STAGE II compliant
The graphs below compare the emissions of the old ADE and new CAT engines to the EU and US regulatory standards





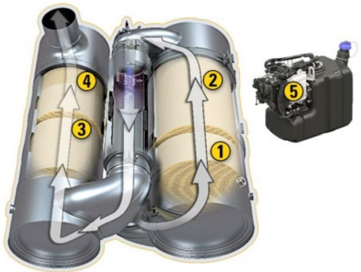




Historic - Exhaust Emissions Investigation

Investigation into using cleaner Low Sulphur Polar Diesel and/or Jet-A1 fuel

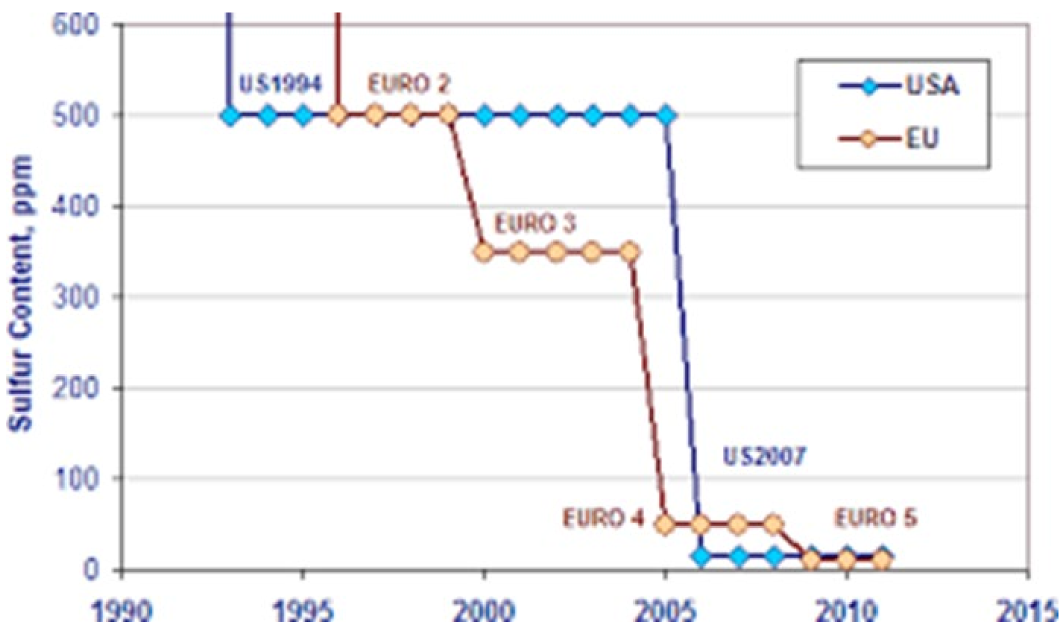
SO² is generated from the sulphur present in diesel fuel
The presence of SO² in the exhaust gas depends on the sulphur content of the fuel and engine fuel consumption only
SO² reacts easily with other substances to form harmful compounds, e.g. sulphuric acid, sulphurous acid and sulphate particles
Ultra-low-sulphur diesel (ULSD) = diesel fuel refined so that its sulphur content is **15 parts per million (ppm) or less**
Since 2006, almost all of petroleum-based diesel fuel in Europe and North America has been to ULSD specification
**ULSD is not available in South Africa*



In South Africa, since Jan 2006, 2 grades of Diesel fuel have been available:
- Standard Grade Diesel – **500 ppm** Sulphur (max)
- Low Sulphur grade Diesel – **50 ppm** Sulphur (max)

Polar Diesel as supplied by ENGEN is similar to Standard Grade Diesel – 500ppm

Future Mitigating Measures…
- Unclear whether possible to upgrade the Caterpillar CAT C9.3 Generators at SANAE IV from US EPA Tier 3 to US EPA Tier 4 by retrofitting the Caterpillar Clean Emission Module (CEM)
- Because ULSD fuel is required in all Tier 4 Interim/Stage IIIB engines for both regulatory and technical reasons, higher-sulphur fuel will cause operational problems and jeopardize component life



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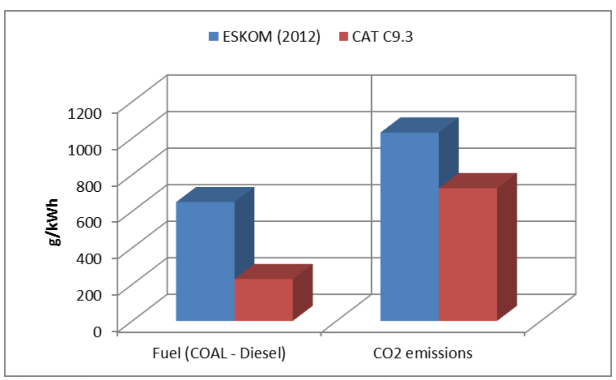
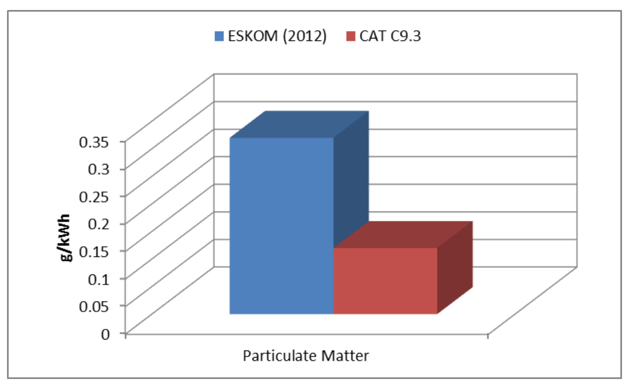
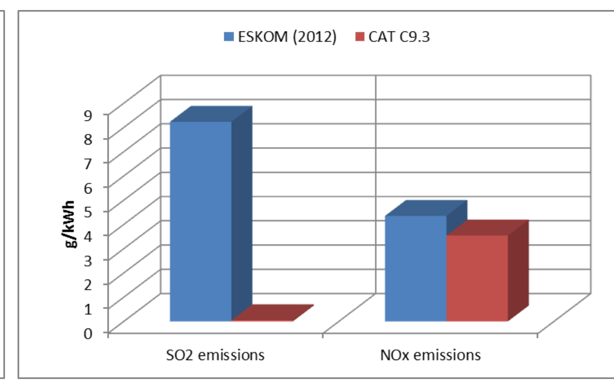
Historic - Exhaust Emissions Investigation

Comparison between emissions generated by CAT C9.3 engines at SANAE IV versus emissions generated by ESKOM's coal power stations for 1kWh unit of electricity generated:

Emissions generated for 1 kWh electricity			
	ESKOM (2012)	**CAT C9.3**	**Unit**
Fuel (COAL - Diesel)	650	229	g/kWh
Particulate Matter	0.32	0.12	g/kWh
CO2 emissions	1030	726	g/kWh
SO2 emissions	8.23	0.046	g/kWh
NOx emissions	4.35	3.54	g/kWh







Source: Eskom Climate Change Fact Sheet (March 2012)

Best Practice Study

Princess Elisabeth Station - *Belgian station, Dronning Maud Land, Antarctica*

- First “ZERO EMISSIONS” scientific research station (2009)
- Site is exposed to winds of up to 300km/hour
- 22 m^2 Thermal Solar panels (12% of energy need)
- 280 m^2 Photovoltaic Solar panels (40% of energy need)
- 9 Wind Turbines (48% of energy need)

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Payback Period

- At SANAE IV station, the hypothetical installation of a 100 kW turbine is estimated to reduce the cost per kWh produced by potentially up to 20%, with a simple undiscounted **payback period of about 10 years** (Teetz et al., 2003).
- A flat-plate solar thermal system at SANAE IV could potentially save over 10,000 liters of fuel annually and have a short **payback period of 6 years** (Teetz et al., 2003).
- Antarctic research stations are often designed for a lifetime of at least 20-25 years. Payback periods of 6-20 years are short in comparison. Such short payback periods should largely justify the costs of investing into energy efficiency and renewable energy applications, especially as more collective experience is accrued and best practices can be shared.

Draft - Research Projects

- **WASTE HEAT RECOVERY** upgrades for Marion and Gough bases
- **PASSIVE BUILDING Design Techniques** for the new Gough base
- **Renewable Energy SOLAR** projects at SANAE IV, Marion and Gough islands
- **Renewable Energy WIND** projects at SANAE IV, Marion and Gough islands
- **TRANSPORT cost optimisation** (Vehicles, Sledges & Routes)
- **EXHAUST EMISSIONS improvement** (Engines, Fuel & Exhaust scrubbers)
- **Mitigating SNOWDRIFT** at the SANAE IV research station (CFD simulation)

Questions ?