The Potential of Large-scale Implementation of Solar Thermal Technologies in South African Hospitals

International Sustainable Energy Conference (ISEC) 2018

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES

Angelo Ian Buckley & Karin Kritzinger

3 – 5 October 2018

Congress Graz, Graz, Austria

science & technology
Department: Science and Technology
REPUBLIC OF SOUTH AFRICA

NRF National Research Foundation

Eskom

sasol reaching new frontiers

UNIVERSITEIT STELLENBOSCH UNIVERSITY

Report Publication

Potential for Solar Thermal Heating South African Hospitals

Project: World Wildlife Fund for Nature South Africa (WWF-SA)
Authored: The Centre for Renewable and Sustainable Energy Studies (CRSES)
Funded: WWF Nedbank Green Trust Fund

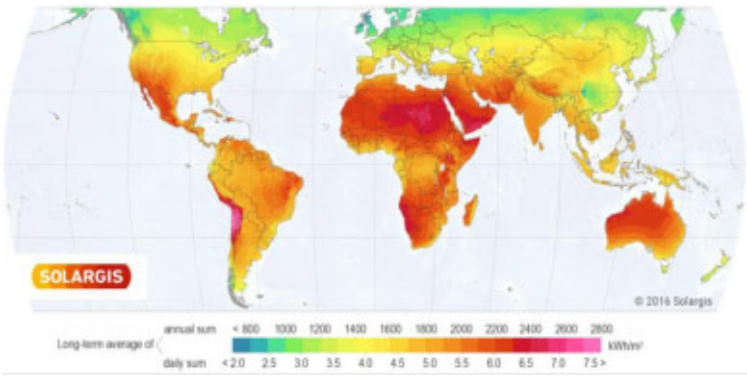
Available: http://www.wwf.org.za/our_research/publications/

Overview

- Introduction
- Overview of the solar resource and hospitals in South Africa
- Current status of large-scale ST applications in South Africa
- Characterisation of the heat demand
- Potential of ST technologies for hospitals in South Africa
  - Current heating technologies used in hospitals
  - Case Study: Paarl Hospital
  - Future projections of ST applications in hospitals
  - Challenges facing the uptake of ST heating in South African hospitals
- Conclusion

Introduction

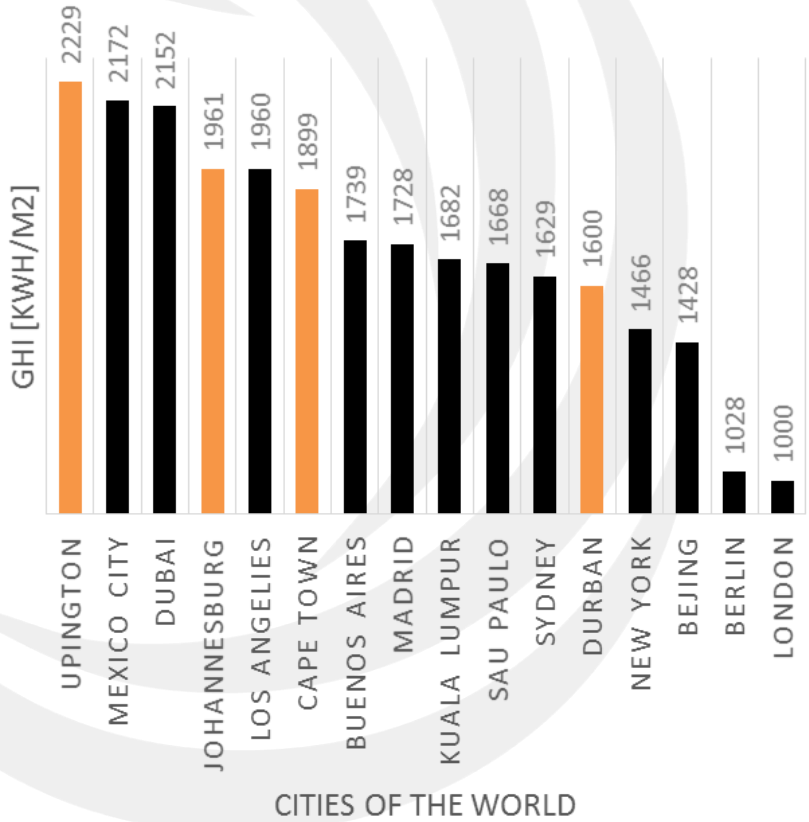
- South Africa has some of the highest levels of solar irradiance in the world
- South Africa has 1 055 MW_{th} of solar thermal installations
- Compared to Germany with 12 281 MW_{th} and Austria with 3 541 MW_{th}
- A lot of its potential which has not been fully exploited
- The health care sector presents high potential, especially in large and small hospitals.
- The study focuses on the use of low-temperature solar thermal technologies (SWH) for supplying the hot water demand in hospitals
- Staff and patient ablutions/domestic purposes in hospitals
- The study focuses on all large and small hospitals in the country which is government and privately owned.



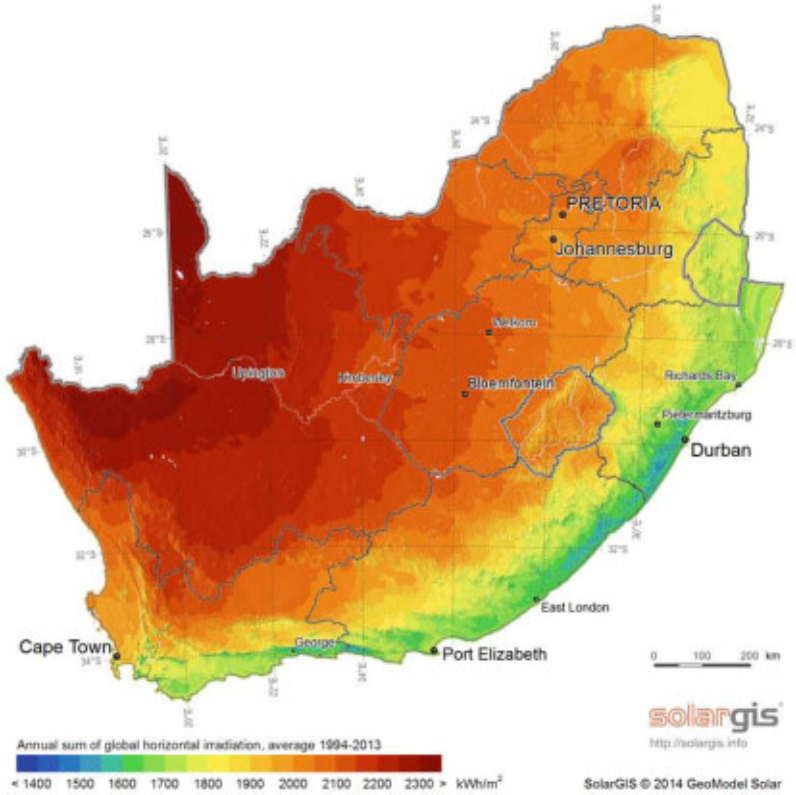
Source: SOLARGIS

Solar Resource (GHI) in South Africa

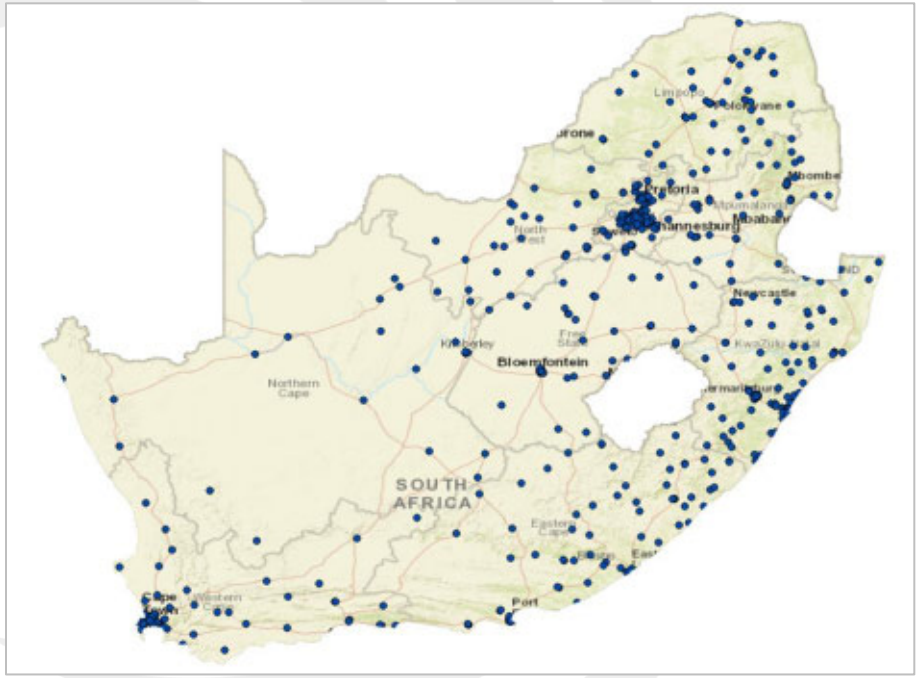
Global

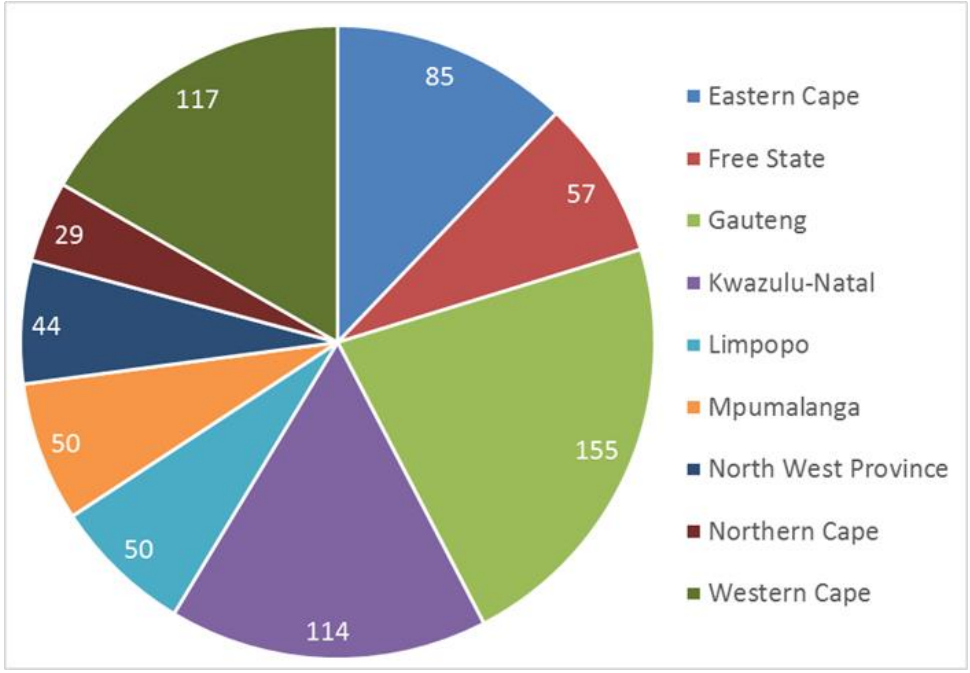


Local



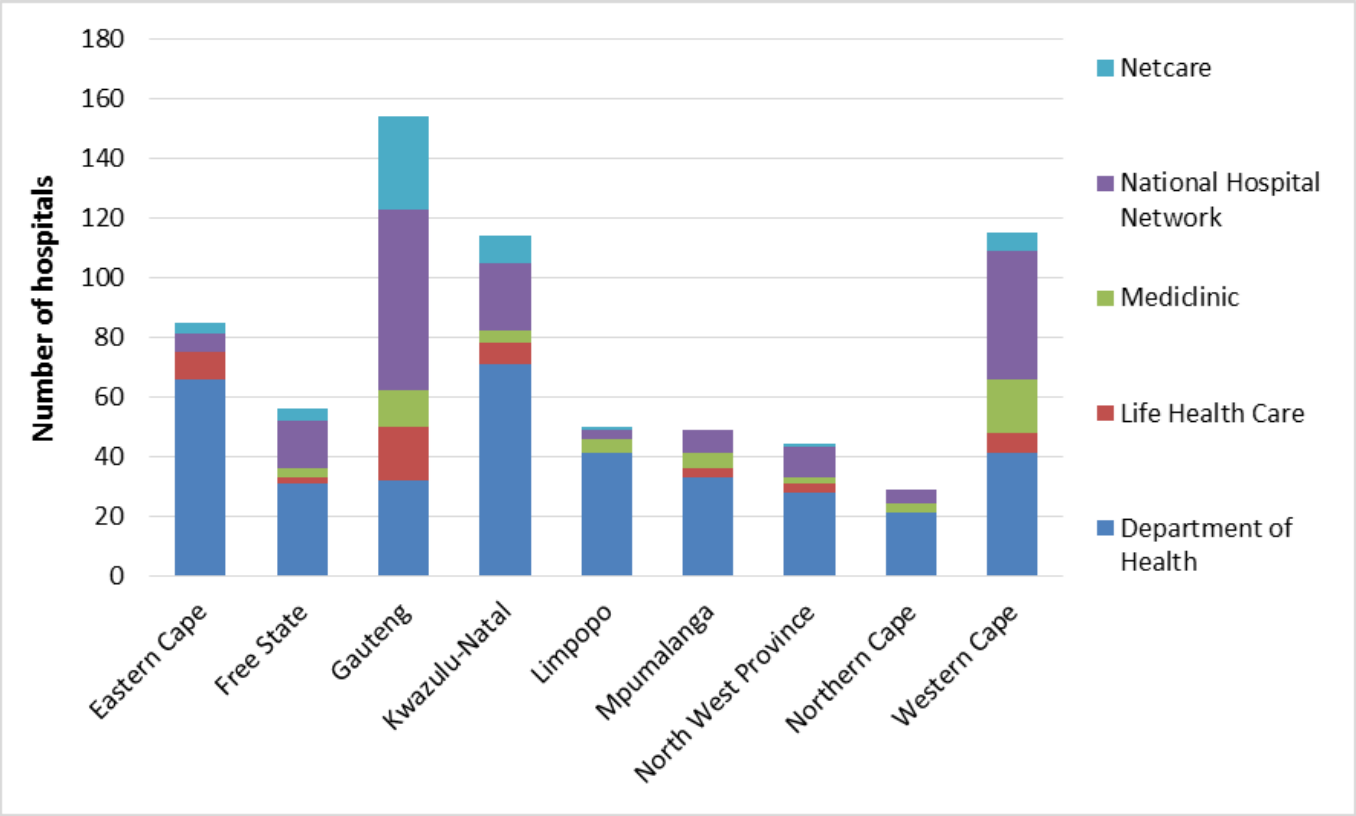
Overview of Hospitals in South Africa





Map of geographical location of SA hospitals (Left). Chart of the number of hospitals per province in SA. A total of 696 hospitals in South Africa accounting for 126 490 beds. Most hospitals densely located around major cities of SA. Most hospitals located in Gauteng

Overview of Hospitals in South Africa



Number of hospitals per province in South Africa based on management. Large provincial hospitals managed by provincial health departments on district level accounts for 52% of hospitals in SA while 48% is privately owned.

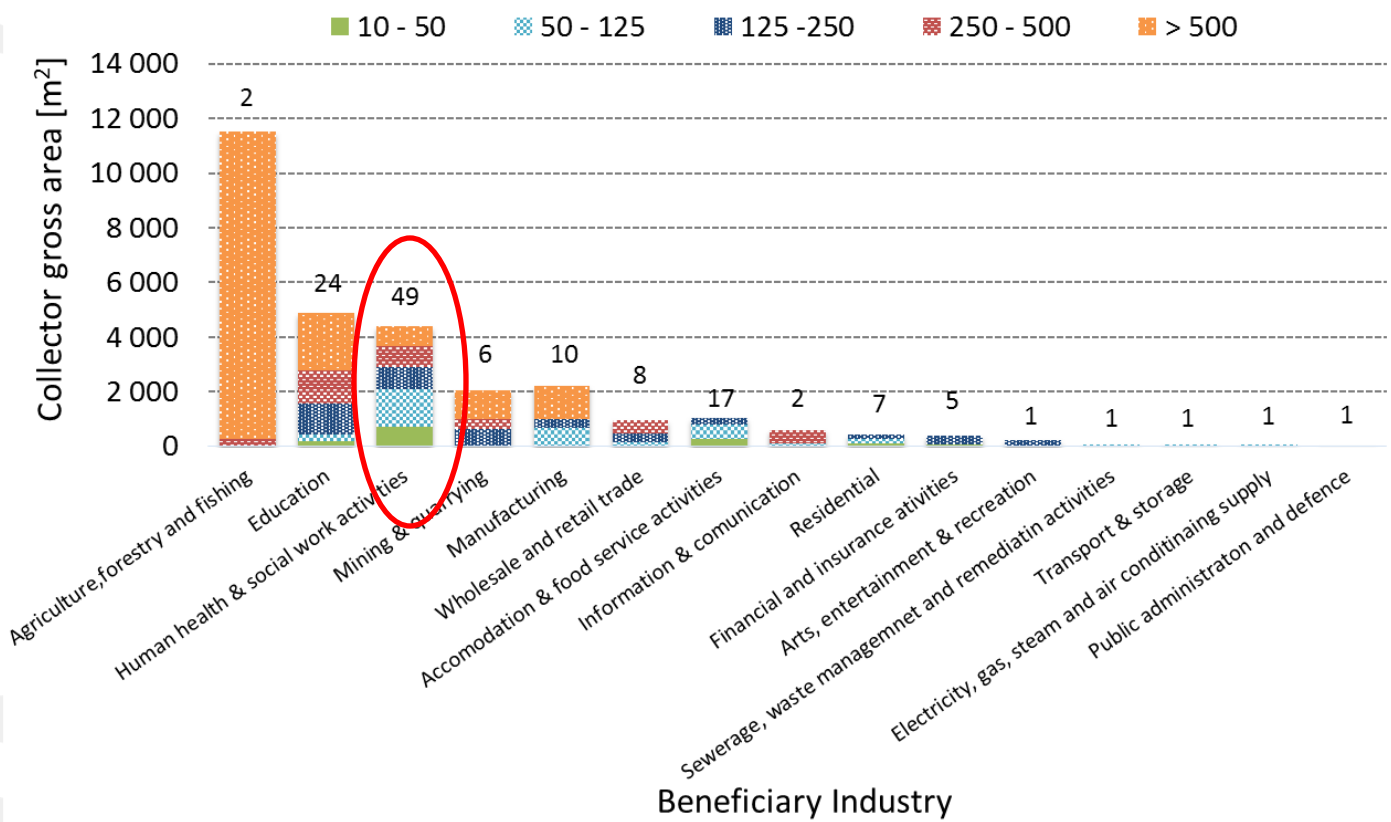
Status of Large-Scale ST Installations in SA

CRSES Large-scale ST Database Overview

- Data
  - Installer name
  - Beneficiary name + industry
  - Application
  - Location
  - Collector type
  - Gross area
  - Storage volume
  - Backup heating
  - Year commissioned
  - Total cost
  - Subsidy
- Statistics
  - Number of systems = 135
  - Dates = 2006 to 2017
  - Total gross area = 29 058 m^2
- Sources
  - Blackdot Energy
  - Soltrain 1, 2 & 3
  - Installers
  - Past projects
- Collector gross area > 10m^2
- Limitations
  - Little information
  - Little cost data
  - With/without storage
  - With/without backup heating elements
  - Work in progress
- Confidence levels
  - High confidence > 50m^2
  - Lower confidence < 50m^2

Status of Large-Scale ST Installations in SA

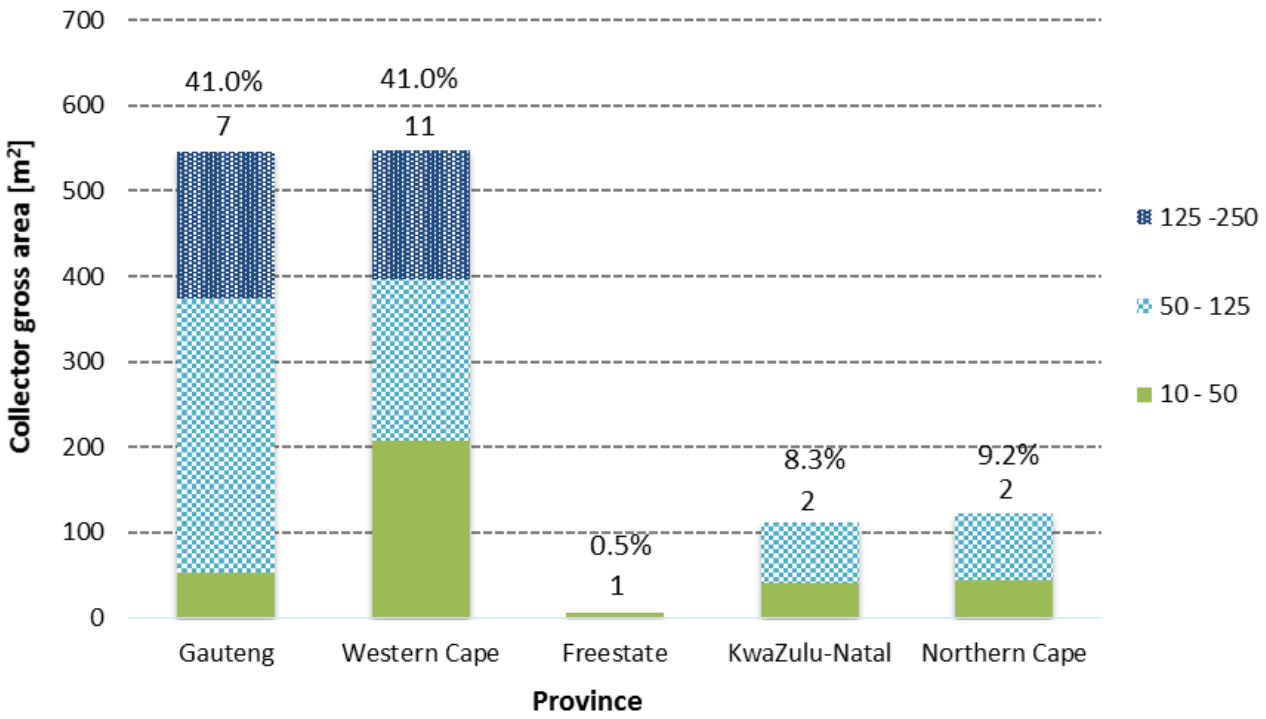
Beneficiary Industry



Large-scale solar water heating systems in SA per beneficiary industry or business category from 2002 to 2017 (gross collector area > 10 m²). Number of systems are indicated above each category. Categorised according to SIC of Economic Activity. Legend units are m².

Status of Large-Scale ST Installations in SA

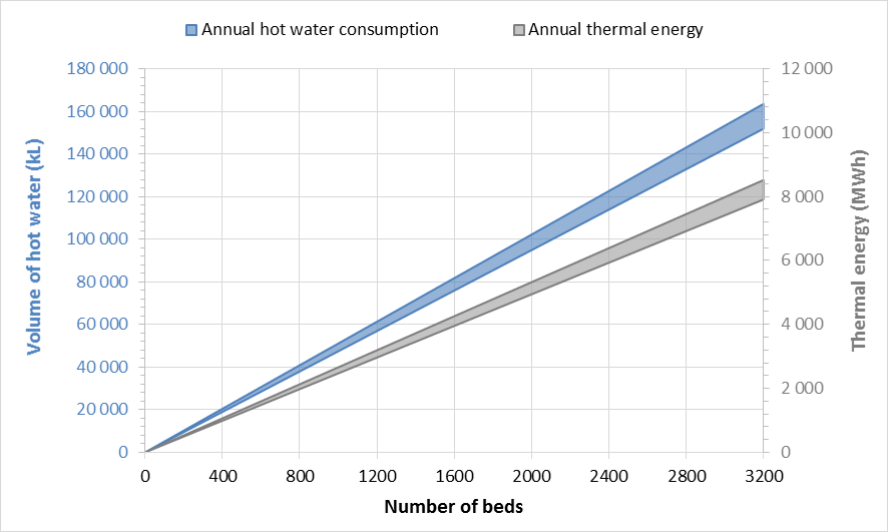
ST Installations at SA hospitals per province



Large-scale solar water heating systems installed SA hospitals per province from 2002 to 2017 (gross collector area > 10 m^2). A total of 23 ST system with gross collector area of 1 333 m^2. The number units is the total in m^2 and represented on a percentage of total collector area installed in SA hospitals.

Characterisation of SA Hospitals Heat Demand

- SANS 10252-1: 2012 - Water Supply and drainage for buildings Part 1 - general principles for the design, installation, and testing of water installations for buildings
- SANS 10252-1 used to establish relationship between cold and hot water consumption of hospitals total bed number in hospitals
- This relationship was used to determine the overall heat demand of 696 hospitals



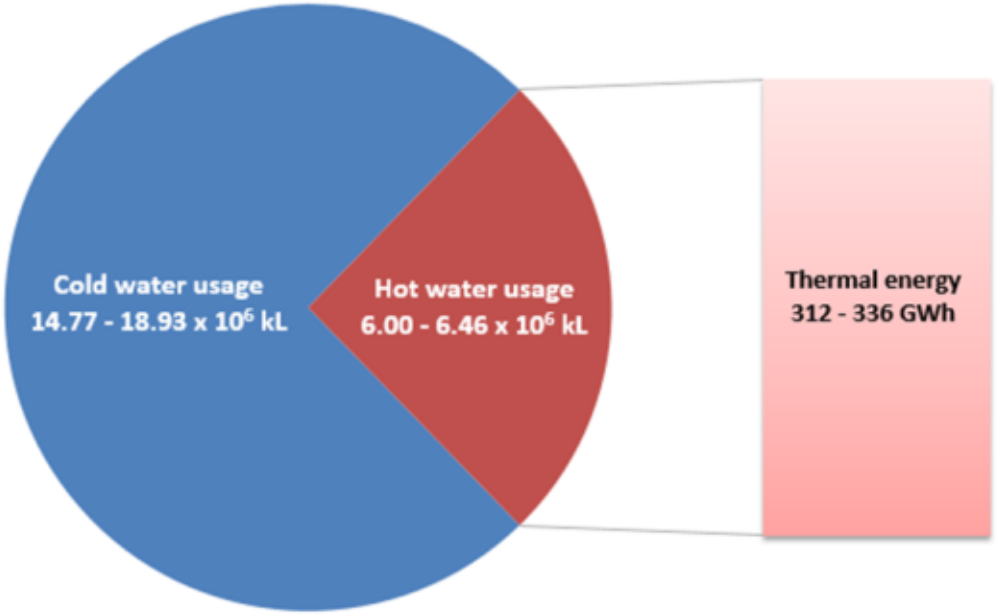
SANS 10252-1 relationship between cold and hot water consumption and number of beds

Function of Hospital	Total hot water demand	Storage volume at 60 °C	Heat power (Direct electrical heating elements only)
General	130 – 140 ℓ/bed/day	20 – 30 ℓ/bed/day	1 – 1.5 kW/bed
Infectious	220 – 230 ℓ/bed/day	40 – 50 ℓ/bed/day	1.5 – 2 kW/bed
Infirmaries	65 – 75 ℓ/capita/day	20 – 25 ℓ/capita/day	0.9 – 1.2 kW/capita/day
Infirmaries and laundry	85 – 95 ℓ/capita/day	25 – 30 ℓ/capita/day	1 – 1.4 kW/capita/day
Maternity	220 – 230 ℓ/bed/day	30 – 35 ℓ/bed/day	1.5 – 2 kW/bed
Mental	85 – 95 ℓ/capita/day	20 – 25 ℓ/capita/day	1 – 1.4 kW/capita/day
Nurses' homes	120 – 130 ℓ/capita/day	40 – 50 ℓ/capita/day	1 – 1.5 kW/bed

SANS 10252-1:2012 design guidelines for cold and hot water consumption in for hospitals with different facilities and functions

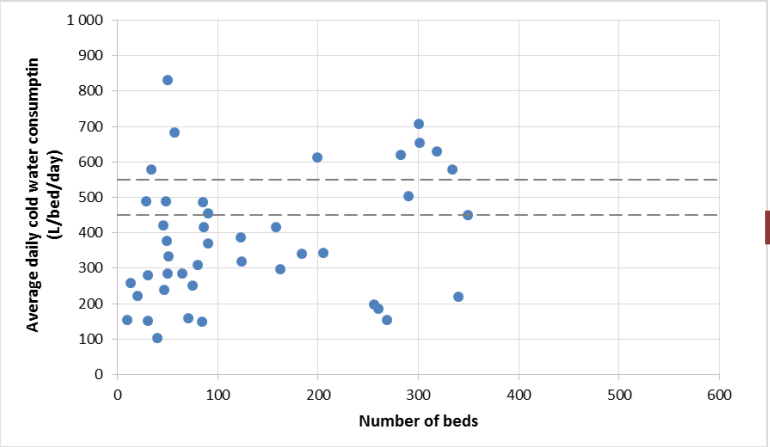
Characterisation of SA Hospitals Heat Demand

- The total annual heat demand of all 696 hospitals determined 312 to 336 GWh/year
- Heat demand fro staff and patient ablution/domestic purposes
- More accurate estimation using actual hot water consumption
- Limitation in the data available
- Western Cape Department of Health agreed to share data for 52 hospitals under management
- Only cold water usage data available
- Used to determine realistic heat demand of all hospitals

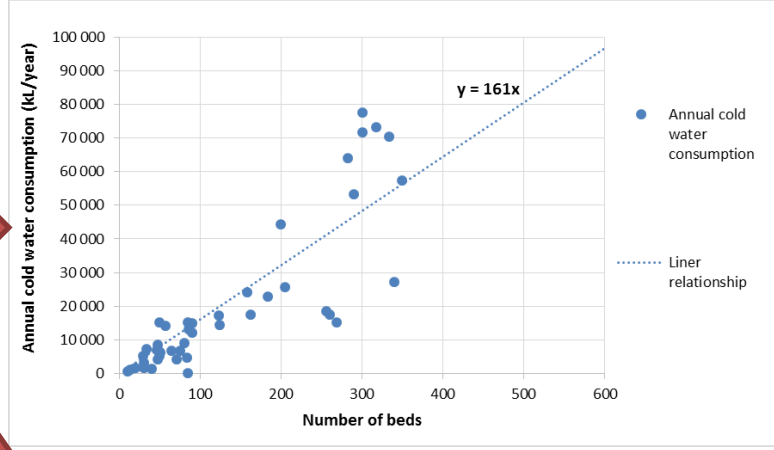


Estimated annual heat demand of all 696 hospitals in South Africa using hot water consumption figure provided in SANS 10252-1: 2012

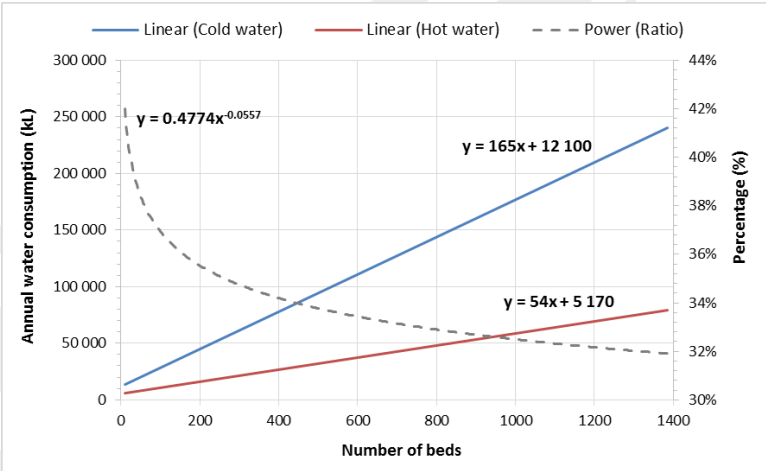
Characterisation of SA Hospitals Heat Demand



Average daily cold water consumption per bed of 52 hospitals managed by Western Cape department of Health



Annual cold-water consumption of Western Cape Department of Health hospitals and linear relationship

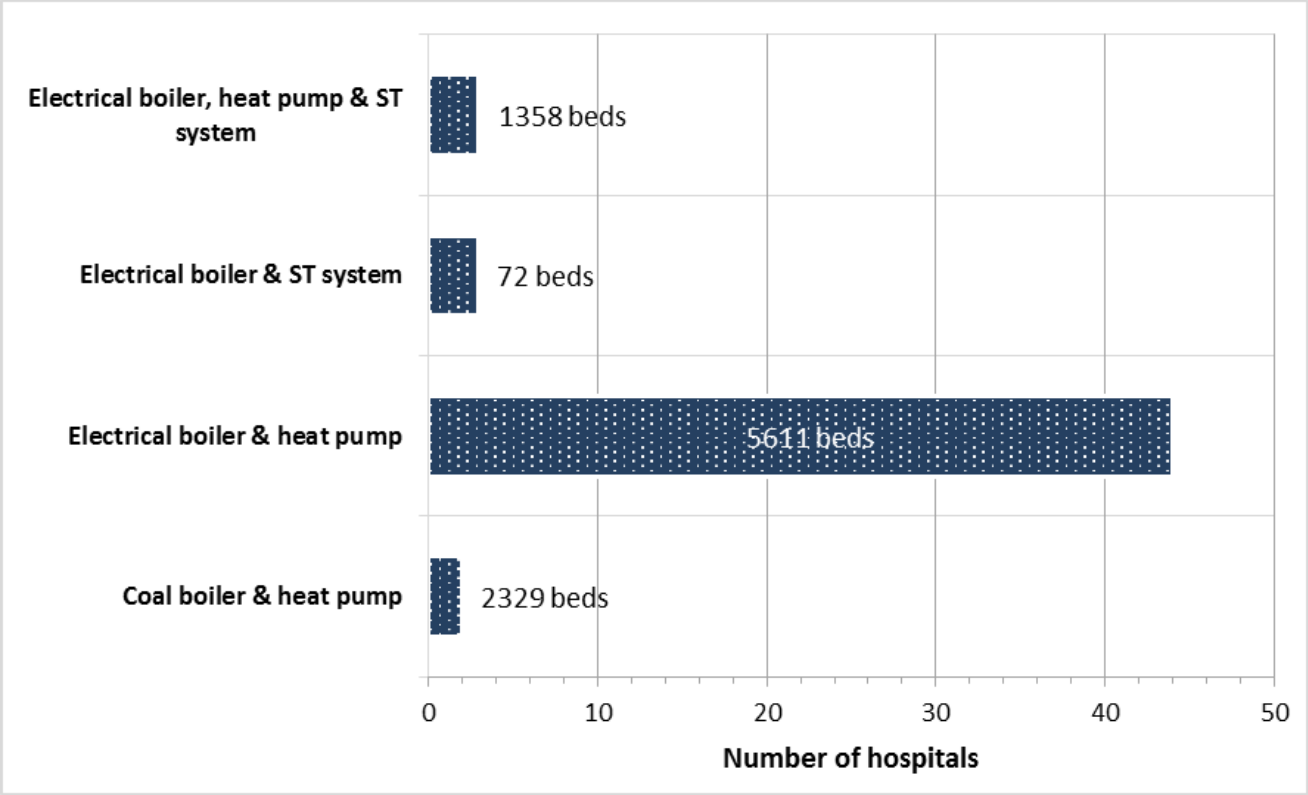


Relationship between the annual cold and hot water consumption in hospitals based on number of beds (Garcia-Sanz-Calcedo, et al., 2017)

Cold water	Annual consumption	**20 394 109 kℓ**
	Average daily cold water consumption per bed	**442 ℓ/bed/day**
Hot water	Annual consumption	**7 099 964 kℓ**
	Average daily hot water consumption per bed	**154 ℓ/bed/day**
Thermal energy	Annual thermal energy demand	**370 GWh**

Potential for ST Technologies in SA Hospitals

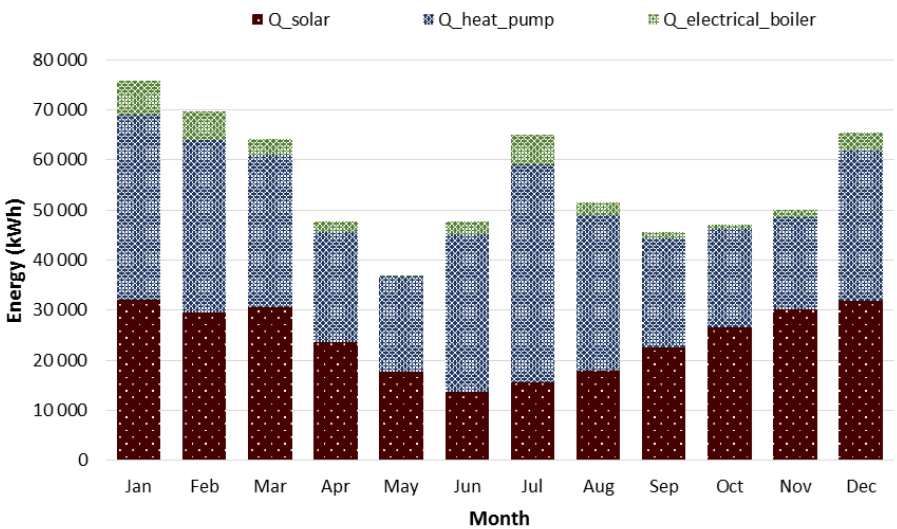
Current heating technologies used in hospitals



Thermal technologies used by hospitals managed by the Western Cape Department of Health based on number of hospitals (x-axis) and overall bed-count (label) in each category. Most hospitals (44) have electrical boiler and heat pump combination installed. Large and older hospitals (2) have coal boilers and heat pump combinations.

Potential for ST Technologies in SA Hospitals

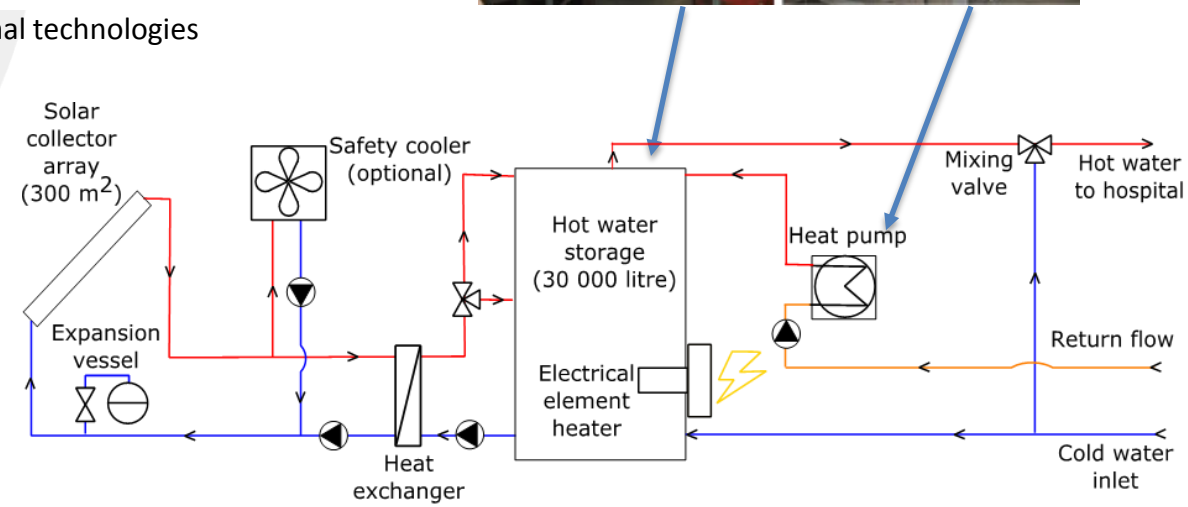
Case study: Paarl Hospital



Monthly energy input from thermal technologies

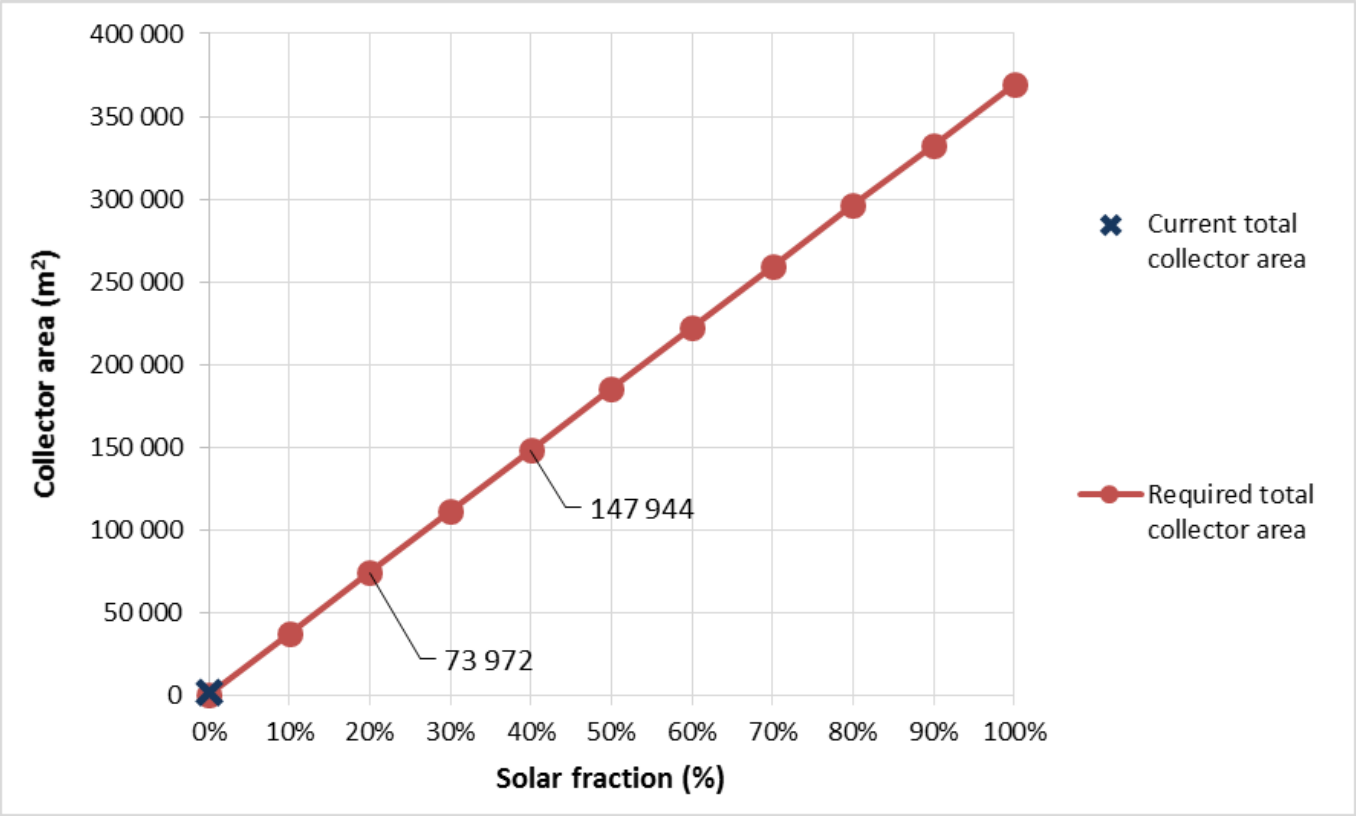
Key results of feasibility case study

- Heat demand = 666 582 kWh
- 300 m^2 ST system with 30 m^2 storage
- Solar fraction = 44%
- Cost = R 1.9 million
- IRR = 10%
- Payback period = 12.3 years
- LCOH with ST system = 0.62 ZAR/kWh
- LCOH without ST system = 0.88 ZAR/kWh



Potential for ST Technologies in SA Hospitals

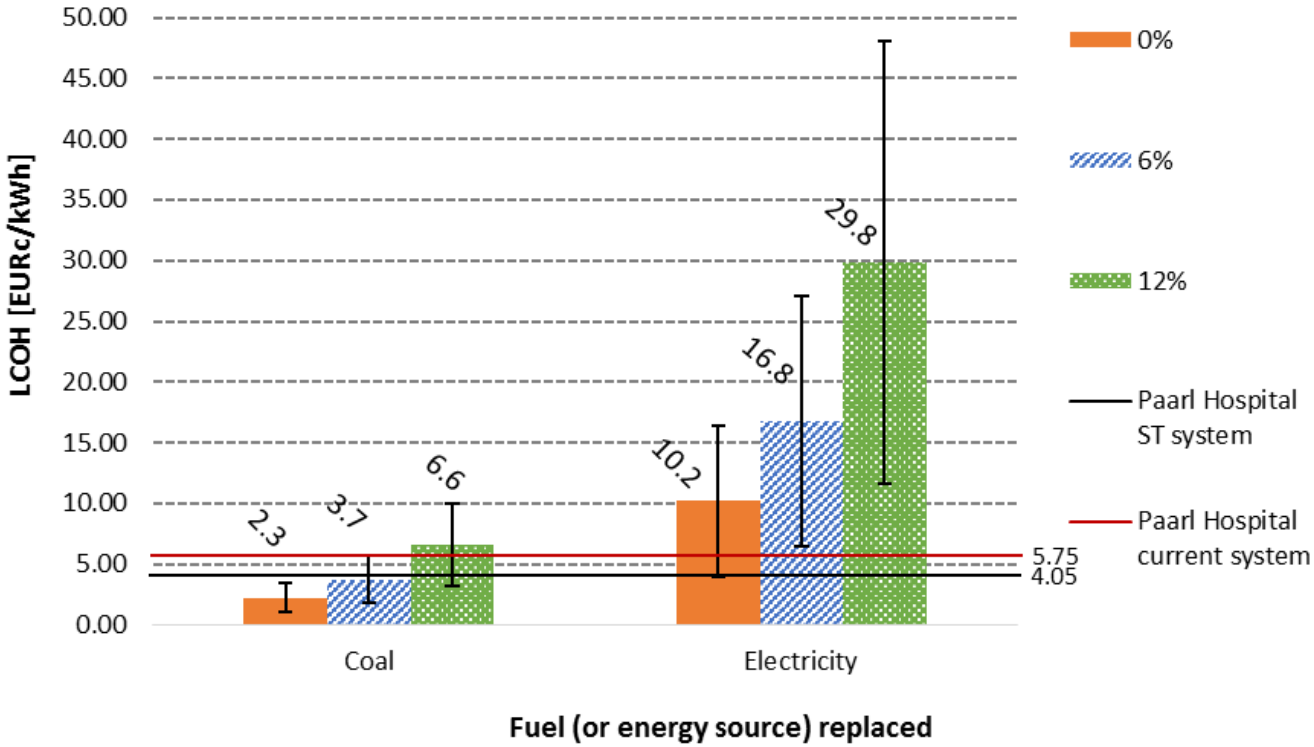
Future projections for ST in SA hospitals



Realistically ST has potential to offset 20% to 40% of hospitals heat demand in SA. This corresponds the installation of 73 972 to 147 944 m^2 gross collector area across 696 hospitals. Currently the 1 333 m^2 accounts for 0.4% of the hospitals heat demand.

Potential for ST Technologies in SA Hospitals

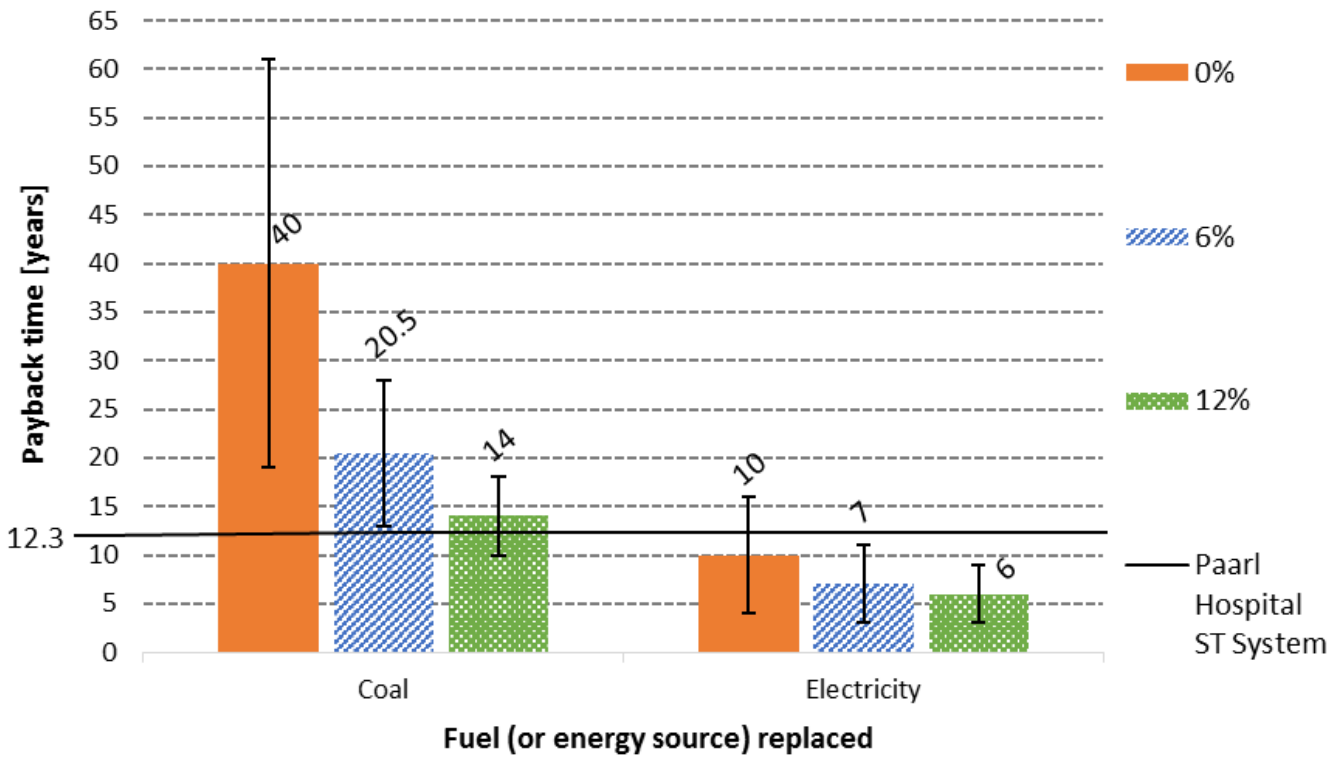
Future projections for ST in SA hospitals



Levelised cost of heat (LCOH) of large-scale ST system in South Africa assuming a 0%, 6% and 12% year-on-year increase in cost of energy from coal and electricity over a 20 year period. Developed using a exchange rate of 15.30 ZAR/EURO (Joubert, et al., 2016). The results of the Paarl Hospital case study shows a LCOH of 4.05 EUROc/kWh (0.62 ZAR/kWh) is achievable supplementing heat pumps and electrical boiler system with an LCOH of 5.75 EUROc//kWh (0.88 ZAR/kWh).

Potential for ST Technologies in SA Hospitals

Future projections for ST in SA hospitals



Amortisation times of large-scale ST system in South Africa assuming a 0%, 6% and 12% year-on-year increase in cost of energy from coal and electricity. Developed using a system specific cost costs 603 EUR/m2 and a exchange rate of 15.30 ZAR/EURO (Joubert, et al., 2016)

Potential for ST Technologies in SA Hospitals

Challenges facing the uptake of ST in SA hospitals

- Lack of data and information on the hot water demand of hospitals
- Solar PV the opted renewable energy alternative
- Existing problem with cold and hot water supply systems
- Storage tank space and replacement
- Asbestos roofs and limited roof space of optimal installations
- Large uptake of heat pumps technologies in hospitals

100 m^2 ST system with 20 m^3 hot water storage including heat pumps in Western Cape, South Africa

Conclusion

- There is still a large potential for ST technologies in supplying the heat demand in South African hospitals
- Small percentage of what is realistically and feasibly possible has been exploited
- With the large use of heat pumps and electrical boiler combination for heat, implementing ST system is still economically feasible, however extended payback periods can be expected.
- Implementing ST system with heat pumps and electrical boilers provides lower LCOH
- ST system proves technically sensible for replacing old coal boiler system in large public hospitals, however would not be financially attractive due to low cost of coal in SA

Thank you for listening

Thanks to AEE-Intec, sponsors and organisers

References

- Anon., 2012. *Standard Industrial Classification of all Economical Activities (SIC) Seventh Edition,* Pretoria, South Africa: Statistics South Africa.
- Anon., 2012. *Standards South African National. Water supply installations for buildings.* Pretoria: (SANS 10252-1: 2012).
- Anon., 2017. *Techno Precision Engineers & Consultants.* [Online]
  Available at: http://www.technoprecision.in/solar-water-heater-accesories.html
- [Accessed 27 July 2017].
- Bujak, J., 2010. Heat consumption for preparing domestic hot water in hospitals. *Energy and Buildings,* Energy and Buildings Heat consumption for preparing domestic hot water in hospitals, Volume 42, pp. 1047 - 1055.
- Eskom, 2017. *Concentrating Solar Power (CSP).* [Online]
  Available at:
  http://www.eskom.co.za/AboutElectricity/RenewableEnergy/ConcentratingSolarPower/Pages/Concentrating_Solar_Power_CSP.aspx
  [Accessed 07 September 2017].
- Garcia-Sanz-Calcedo, J., Lopez-Rodriguez, F., Yusaf, T. & Al-Kassir, A., 2017. Analysis of the average annual consumption in the hospitals of Extremadura (Spain). *Energies,* 10(479), pp. 1 - 10.
- Joubert, E. C., Hess, S. & Van Niekerk, J. L., 2016. Large-scale solar water heating in South Africa: Status, barriers and recommendations. *Renewable Energy Volume,* Volume 97, pp. 809 - 822.
- Mangal, D., Lamba, D. K., Gupta, T. & Jhamb, K., 2010. Ackowledgement of evacuated tube solar water heaters over flat plate solar water heaters. *International Journal of Engineering (IJE),* 4(4), p. 279.
- Venam, 2015. *Flat plate thermal collectors.* [Online]
- Available at: https://www.youtube.com/watch?v=59PSN8TwSKk
- [Accessed 27 July 2017].
- Weiss, W., 2016. *Collectors suitable for Industrial Applications.* AUSTRIA: AEE - Institute for Sustainable Technologies (AEE INTEC).
- Weiss, W., Mauthner, F. & Spörk-dür, M., 2015. *Solar Heat Woldwide.* Austria: Austrian Ministry for Transport, Innovation and Technology.