STERG

SOLAR THERMAL ENERGY RESEARCH GROUP

Long-term energy storage options for CSP and other variable renewable energy in South Africa

Johan D Burger, Thomas M Harms & A Ben Sebitosi

Outline

Brief outline of the presentation:

- Introduction:
  - VRE in South Africa
  - Why storage?
- Storage:
  - Categories of storage
  - Evaluation metrics, what is important?
  - Different types
  - Worldwide research

Outline

Brief outline of the presentation:

- Evaluation method: LCOS & sensitivity analysis
- Recommendations
- Conclusion

Introduction

Variable renewable energy?

- What is VRE?
  - Relies on natural phenomena
  - Fairly unpredictable
  - Cannot function as baseload
- How is the success of RE source defined?
  - How well it matches demand curve

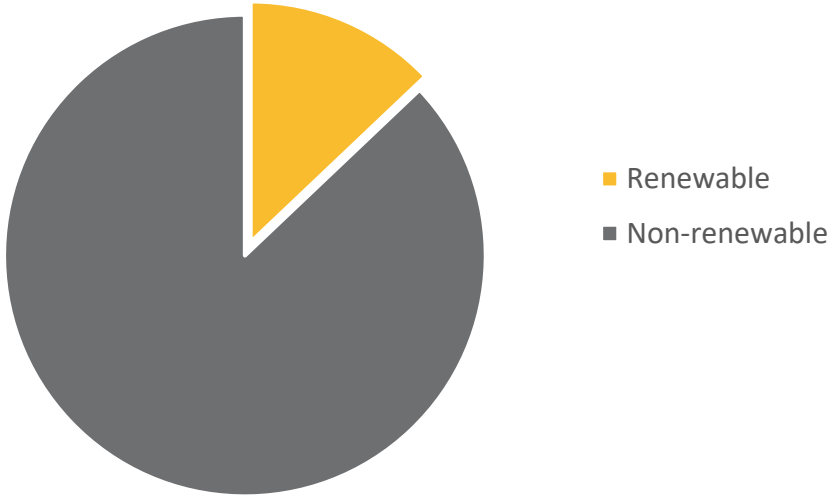
Introduction

VRE in South Africa

- Renewable: 13%
- Non-renewable: 87%

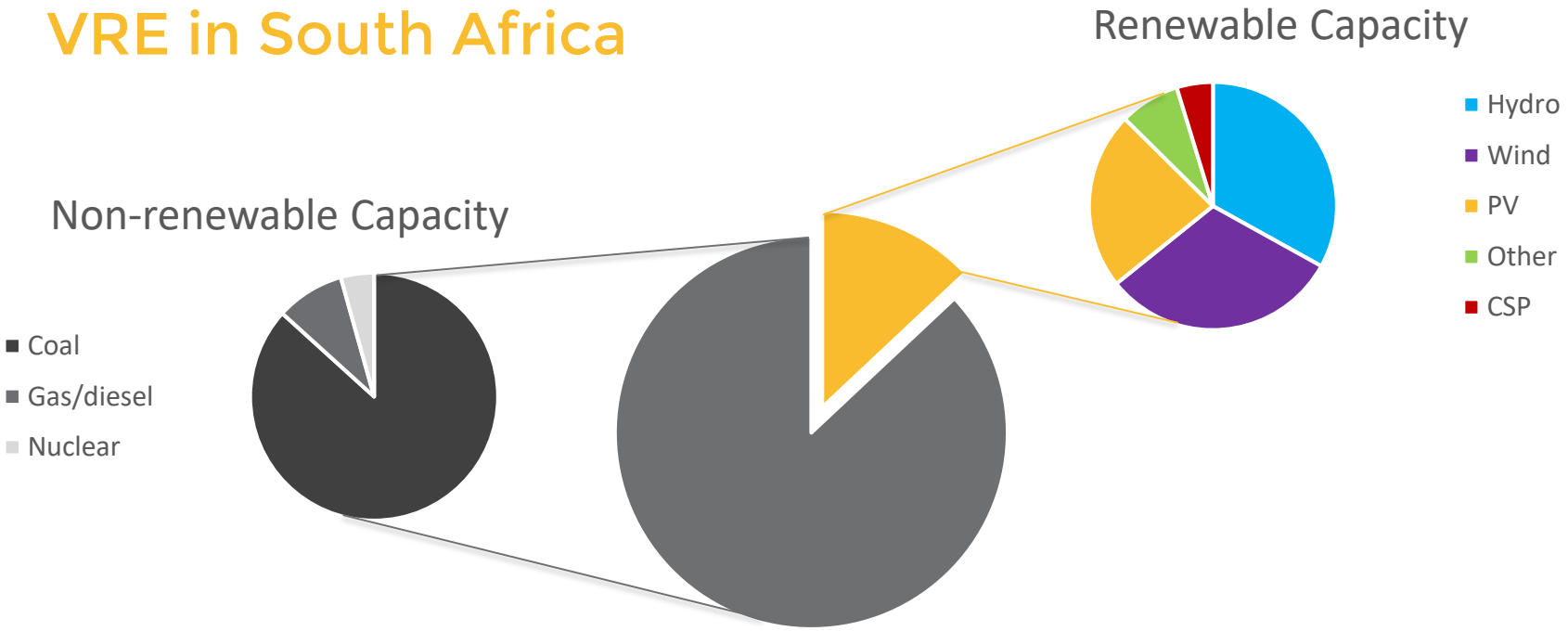
*Information sourced from March 2019 version of the Draft IRP which is subject to change

Installed Capacity 2018 [1]



Introduction

VRE in South Africa



Introduction

VRE in South Africa

- From 2018 Draft IRP, least-cost scenario (IRP1):
  - No annual renewables build limit
  - Cheapest new build option as coal decommissions[2]
    - ≈R15-55 bn/yr cheaper by 2040
    - ≈R30-60 bn/yr cheaper by 2050
  - Least CO_2
  - Greatest reduction in water usage

Introduction

Employment Opportunities

- Anticipated jobs by 2030[1]
  - 246 000 jobs for Solar PV
  - 344 000 jobs for wind

Introduction

VRE in South Africa

- South Africa has an unique opportunity
  - How can we boost VRE build capacity?
  - How can we increase grid penetration?

Introduction

Proposed solution: Storage

- Need for storage:
  - Current VRE cannot function as baseload supplier
  - As VRE penetration grows, need for storage increases
  - Able to store excess energy & prevent curtailment
  - Increased financial security

Storage

Long-term storage

- What defines “long-term?”
- Potential applications
- Limitations

Storage

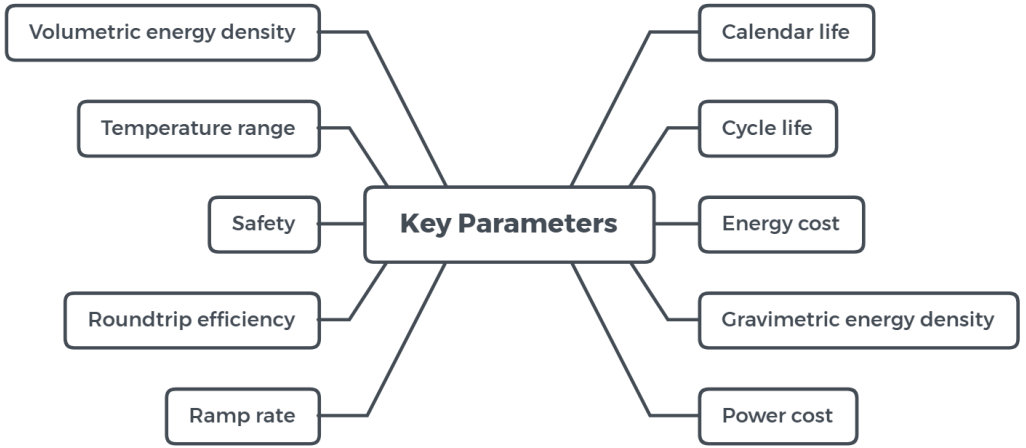
The different categories of storage

- Daily storage
- Weekly storage
- Seasonal storage
- Annual/indefinite storage

Storage

Evaluation metrics, what is important?

The following metrics are important to consider:

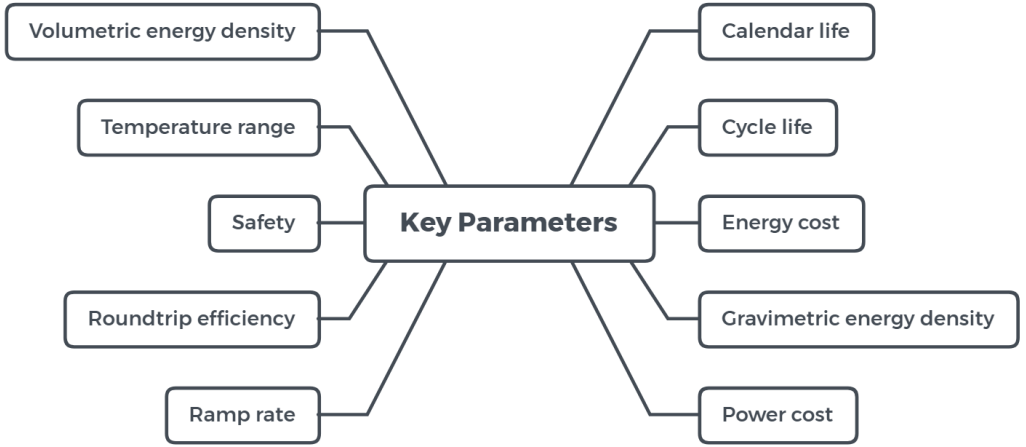


Source: Stanford.edu

Storage

Evaluation metrics, what is important?

Depending on the application, certain parameters become more important than others.



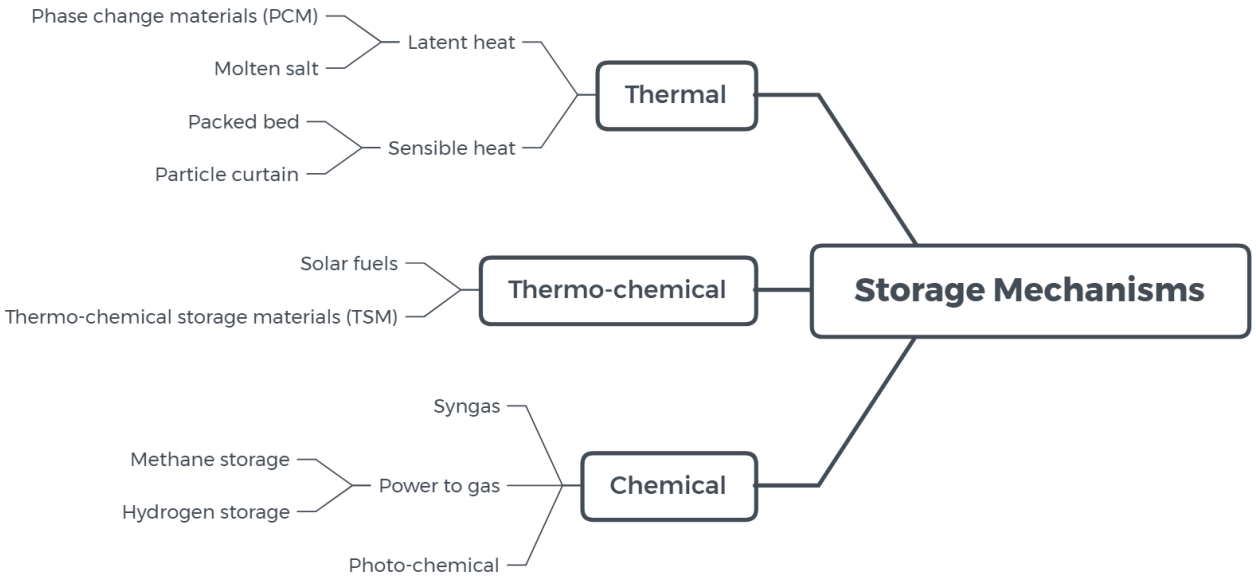
Source: Stanford.edu

Storage

Different storage mechanisms

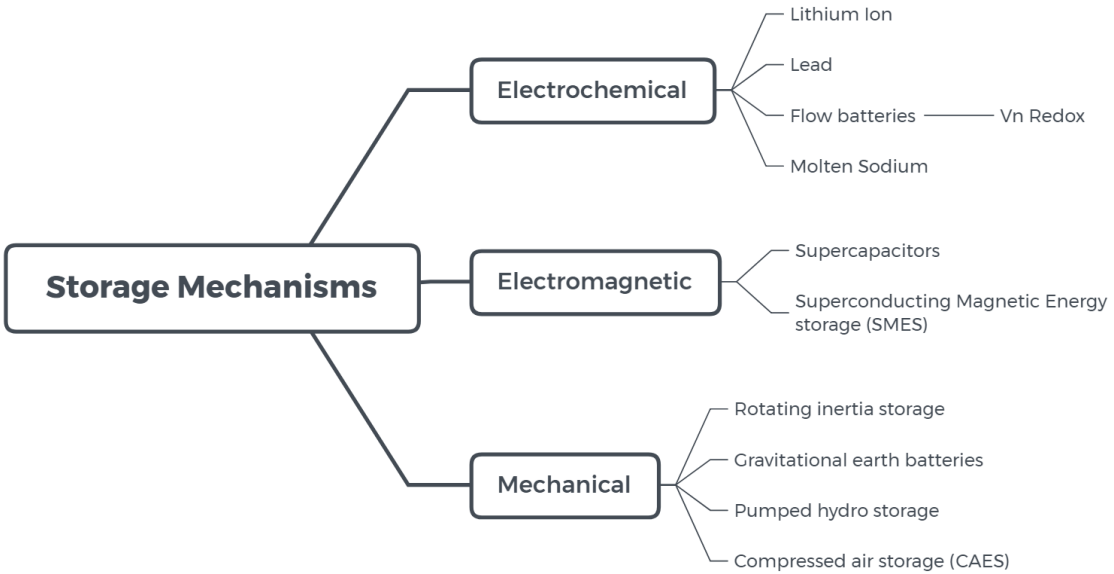
Storage

Different storage mechanisms



Storage

Different storage mechanisms



Storage

Worldwide research

- Current research:
  - International interest
  - Application of technology
- Future research

Energy cost: LCOS

Levelized cost of storage

- Economic evaluation based on:
  - Sensitivity analysis
  - Levelized cost of storage[3]:

$$LCOS = \frac{CAPEX + \sum_{t=1}^{t=n} \frac{A_t}{(1+i)^t}}{\sum_{t=1}^{t=n} \frac{W_{out}}{(1+i)^t}}$$

CAPEX - Capital expenditure for storage

A_t – Annual cost of storage

W_{out} – Annual energy output

i – interest rate

t – year of calculation

n – financial lifetime

Recommendations

Storage solution for SA?

- From research:
  - No single “one size fits all” solution
  - Storage will likely be a per-application approach
    - Long-term (expensive) vs short-term

Recommendations

Long-term storage for CSP

- Thermo-chemical storage
  - Higher energy density storage
  - Possible heat storage at room temperature
  - Constant temperature heat release at restitution temperature set by reaction equilibrium

Recommendations

Short-term storage for CSP

- Latent-heat storage
  - High storage density
  - Heat charging/discharging occurs at a constant temperature

Conclusion

Future of RE in South Africa

- New build RE is largely steered by policy
- Storage will facilitate greater grid penetration
- The application of storage technology will depend on the specific need

THANK YOU

ACKNOWLEDGEMENTS:

Prof TM Harms
Prof AB Sebitosi

CONTACT DETAILS:

Johan D Burger
Solar Thermal Energy Research Group (STERG)
Stellenbosch University
South Africa

STERG@sun.ac.za
+27 (0)21 808 4016

visit us: concentrating.sun.ac.za

References

[1] Department of Energy South Africa, “Integrated Resource Plan (IRP) 2018_Draft Update”, 2019. Accessed on: April 15, 2019. [Online]. Available: https://www.ee.co.za/wp-content/uploads/2019/04/Updated-Draft-IRP2019-6-March-2019.pdf

[2] J. G. Wright, J. Calitz, N. Ntuli, R. Fourie, M. Rampokanyo, and P. Kamera, “Formal comments on the Draft Integrated Resource Plan (IRP) 2018 (Report) v1.2,”, October 2018. Accessed on: Feb 6, 2019. [Online]. Available: https://researchspace.csir.co.za/dspace/handle/10204/10492

[3] V. Jülch, “Comparison of electricity storage options using levelized cost of storage (LCOS) method,” *Applied Energy*, vol. 183, pp. 1594–1606, 2016.