# POWER SYSTEM MODELLING: SUPPORTING THE SOUTH AFRICAN GRID

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Photo by Stefan Els

# SOUTH AFRICA'S CURRENT RENEWABLE ENERGY STATUS

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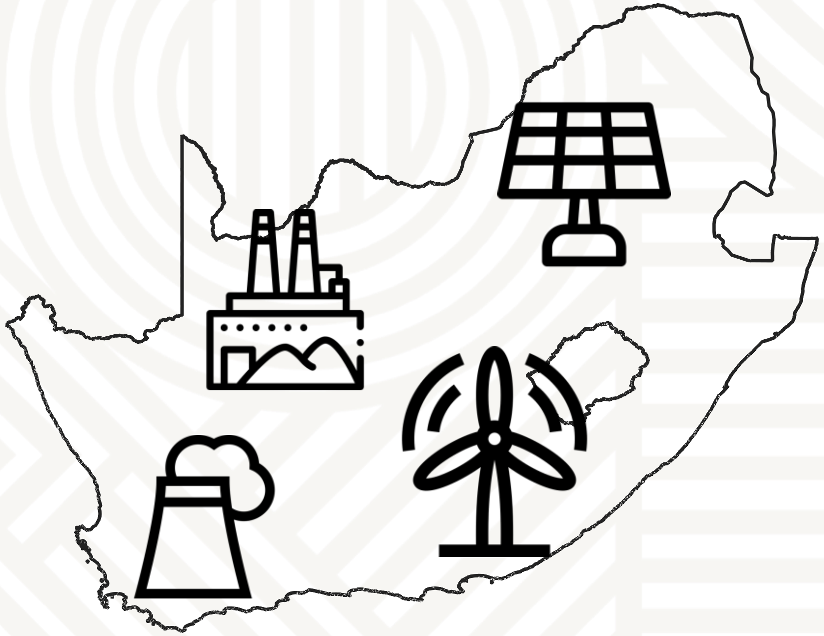


- Nominal energy capacity (Dec 2022): 54.6 GW
- Coal — 39.8 GW
- Nuclear — 1.9 GW
- Diesel (OCGT) — 3.4 GW
- Hydro — 0.6 GW and Pumped storage — 2.7 GW
- Wind — 3.4 GW
- Solar PV — 2.3 GW
- CSP — 0.5 GW

17 % RE capacity to 83 % thermal capacity

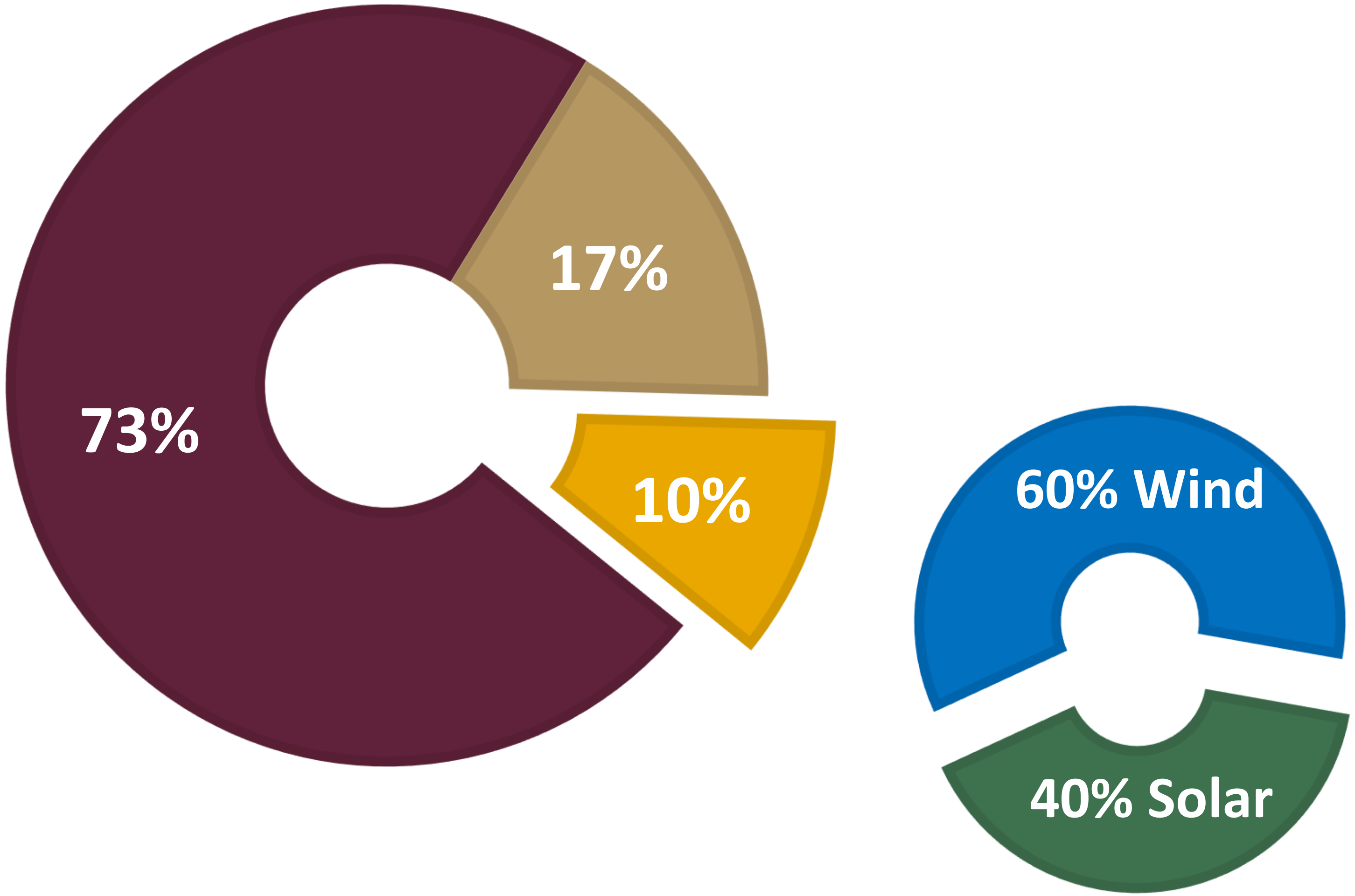
# SOUTH AFRICA'S CURRENT RENEWABLE ENERGY STATUS



Coal **73%**

Wind and Solar PV **10%**

Other **17%**



# SOUTH AFRICA'S PLANNED RENEWABLE ENERGY FUTURE

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| 2030 | Coal | Nuclear | Hydro | Storage | PV | Wind | CSP | Gas & Diesel |
|---|---|---|---|---|---|---|---|---|
| TIC | 33364 | 1860 | 4600 | 5000 | 8288 | 17742 | 600 | 6380 |
| TIC (%) | 43 | 2.36 | 5.84 | 6.35 | 10.52 | 22.53 | 0.76 | 8.10 |
| AEC (% of MWh) | 58.80 | 4.50 | 8.40 | 1.2* | 6.30 | 17.80 | 0.60 | 1.30 |
| TIC | Total Installed Capacity | | | | | | | |
| AEC | Annual Energy Contribution | | | | | | | |

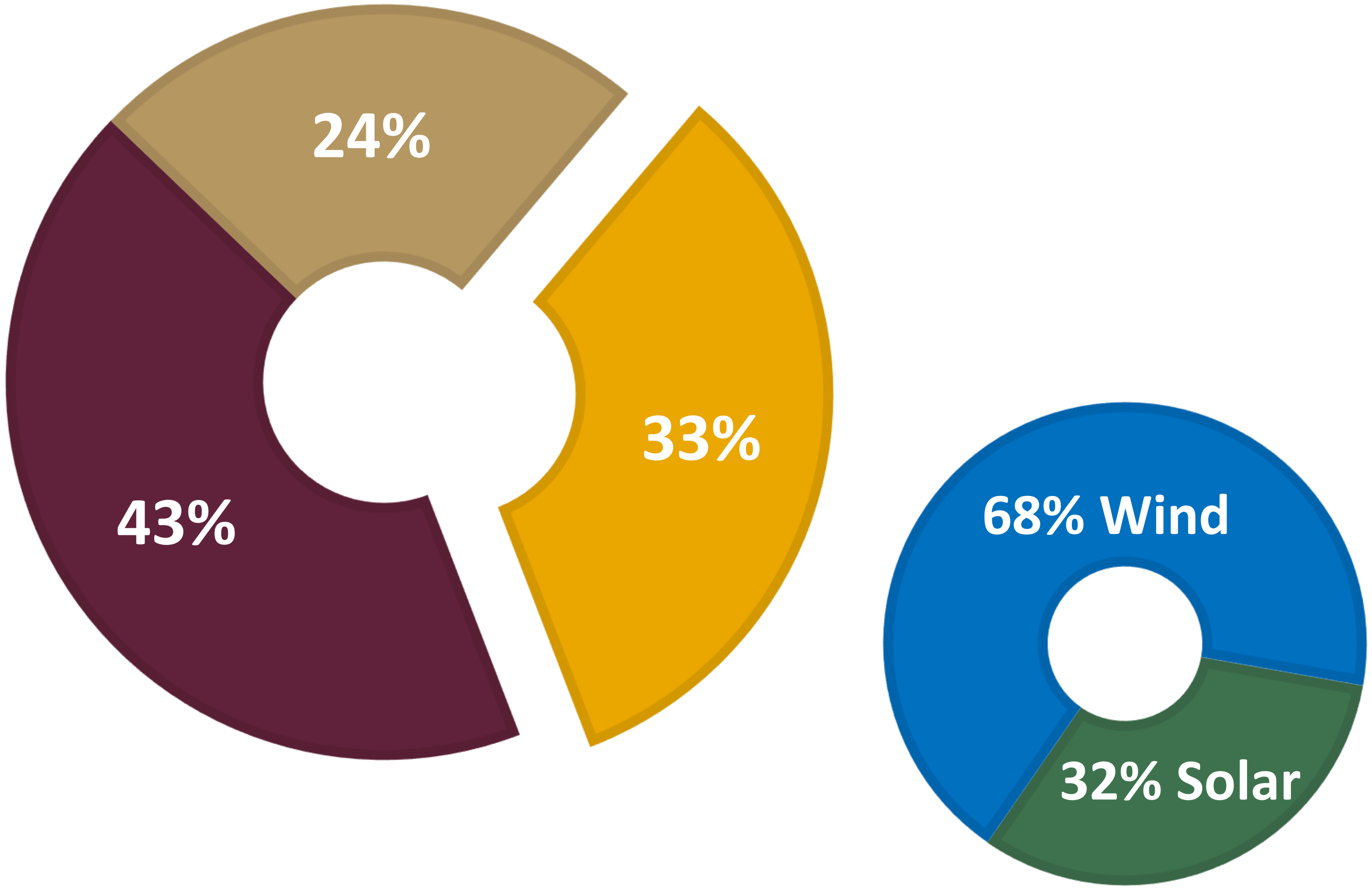
# SOUTH AFRICA'S PLANNED RENEWABLE ENERGY FUTURE



Coal **43%**

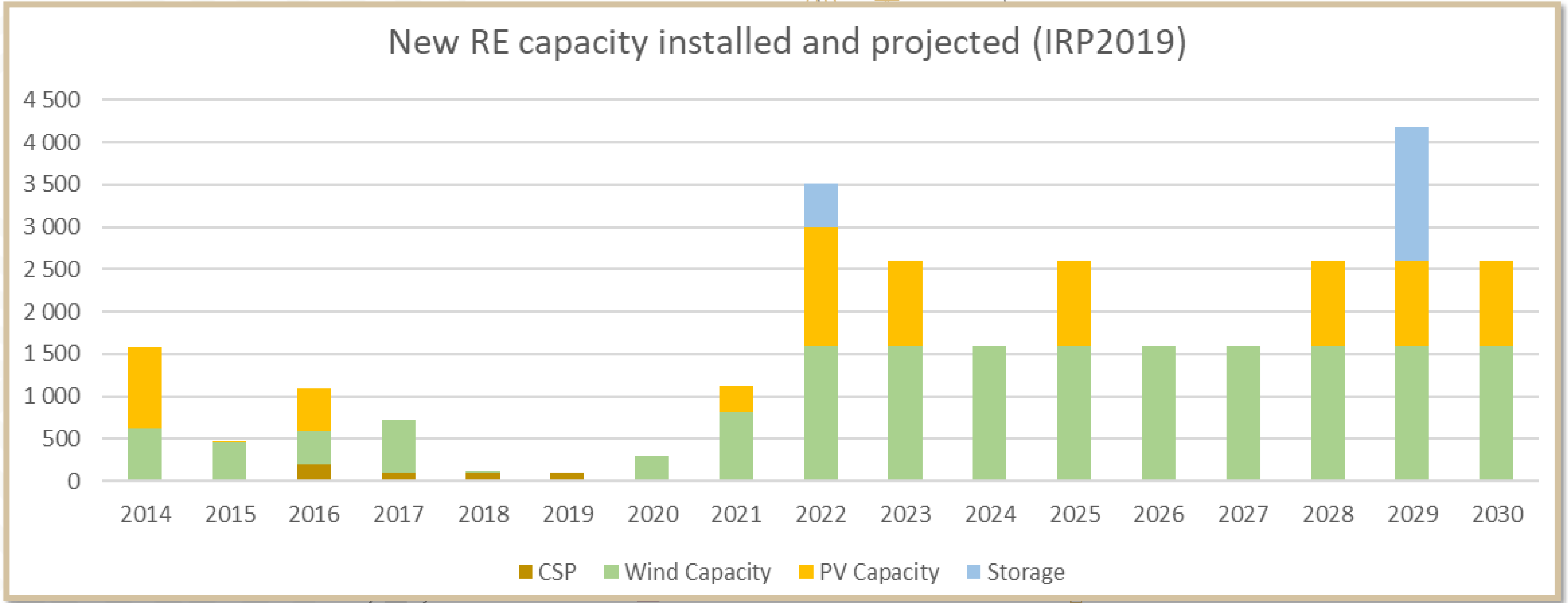
Wind and Solar PV **33%**

Other **24%**



# SOUTH AFRICAS ENERGY INFRASTRUCTURE






49.3 - 73.1
73.1 - 75
75

# WHAT IS THE TRADITIONAL POWER SYSTEM?

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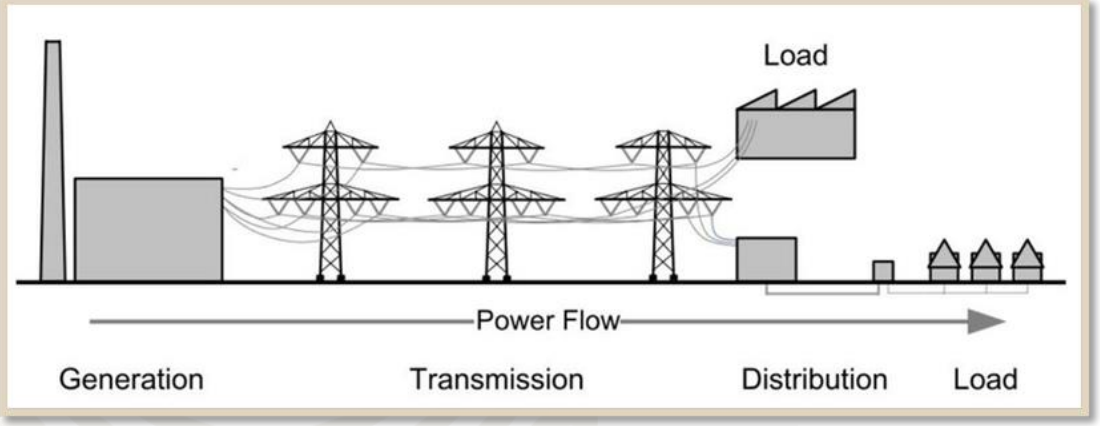
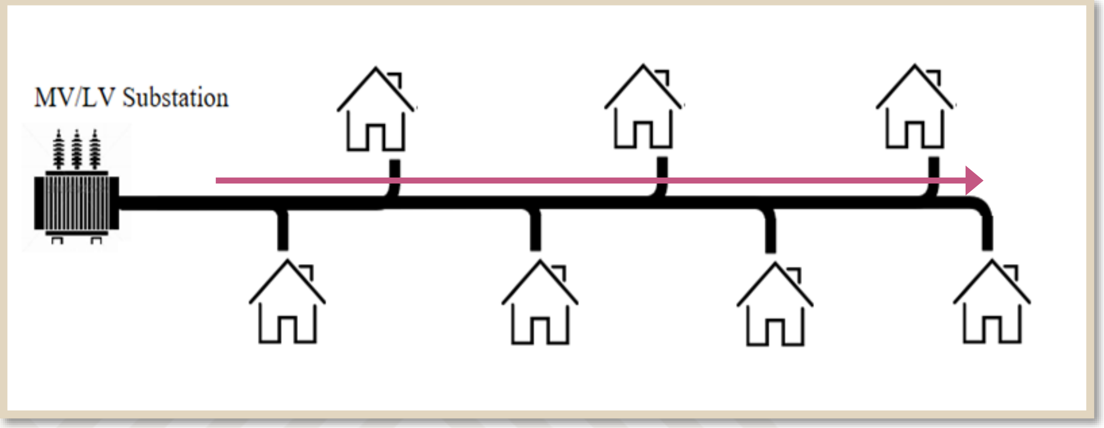
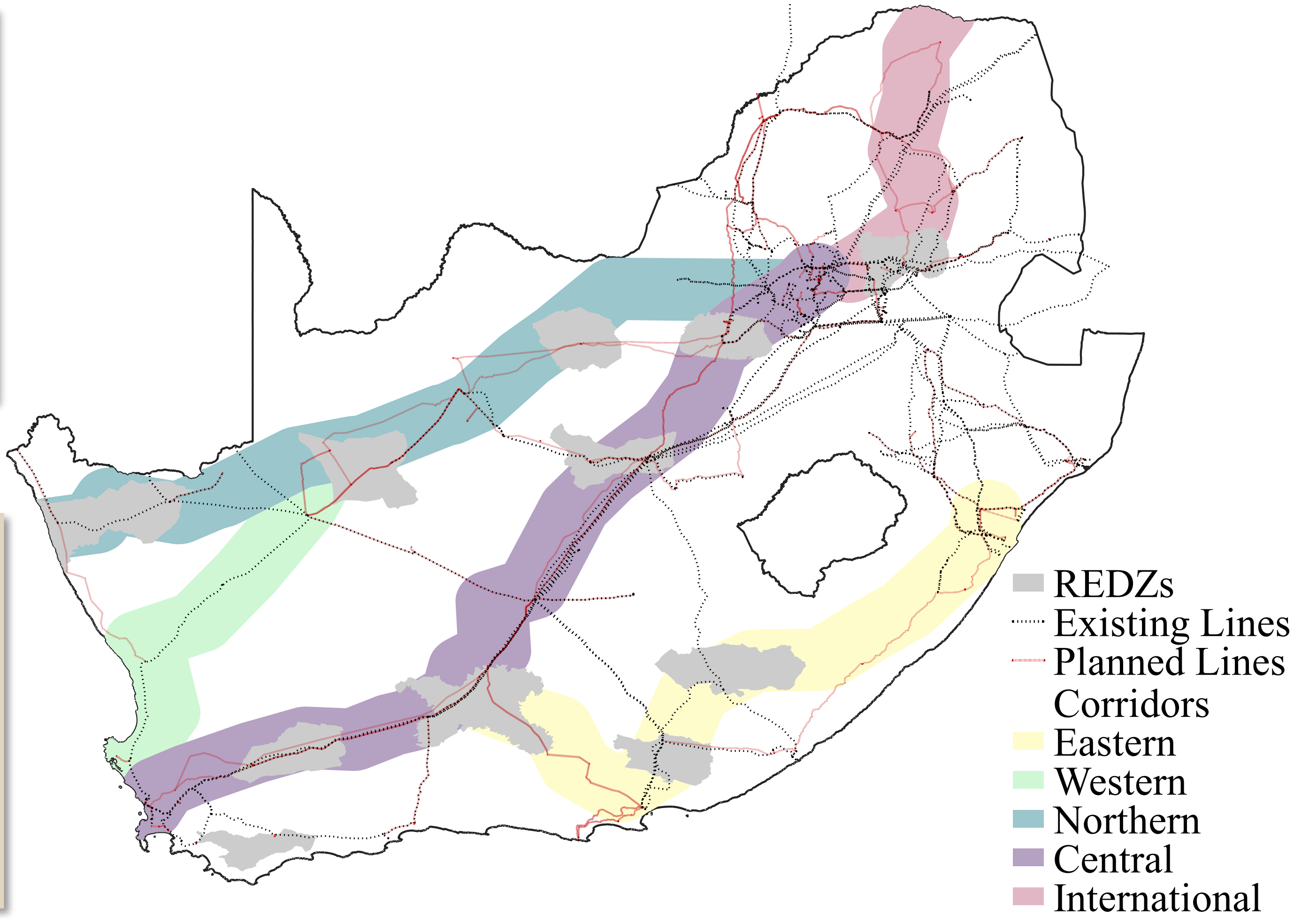
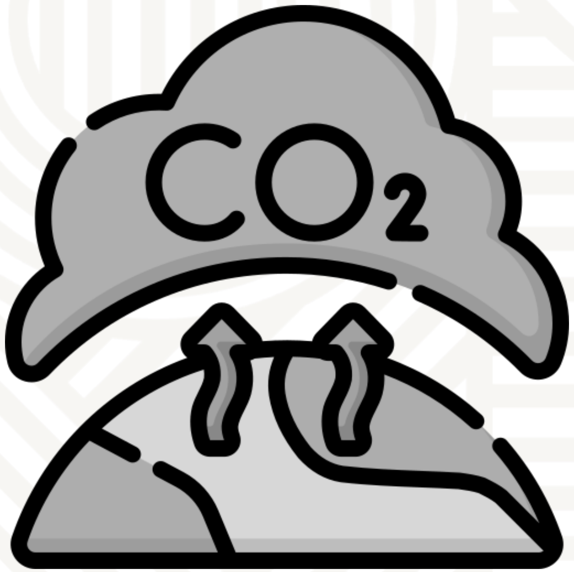


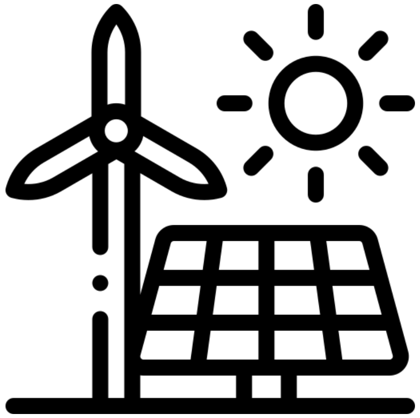



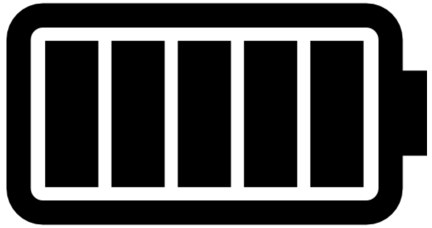



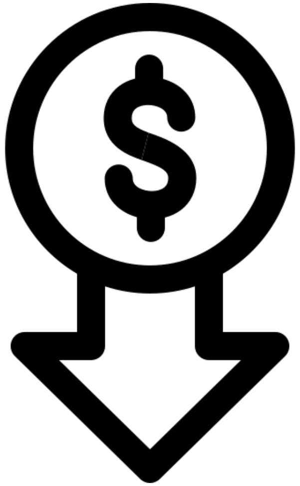
# WHERE ARE WE HEADED?
# WHY SHOULD WE ADAPT?









# FLEXIBILITY IS KEY



**Flexible Generation:** Flexible units (CCGT, Hydro, etc.), Variable Renewable Energy (VRE) curtailment, geospatial dispersion of VRE

**Flexible Load Demand:** Demand response, electric vehicles, power to gas/heat

**Energy Storage:** Batteries, hydrogen, pumped hydro

**Grid Infrastructure:** Transmission level expansion, strengthen distribution

**Improved Operations:** Improved initial and continuous planning, improved VRE forecasting, increased balancing, dynamic energy market design

# Some of the questions we are addressing
## in support of optimal power system planning and operations

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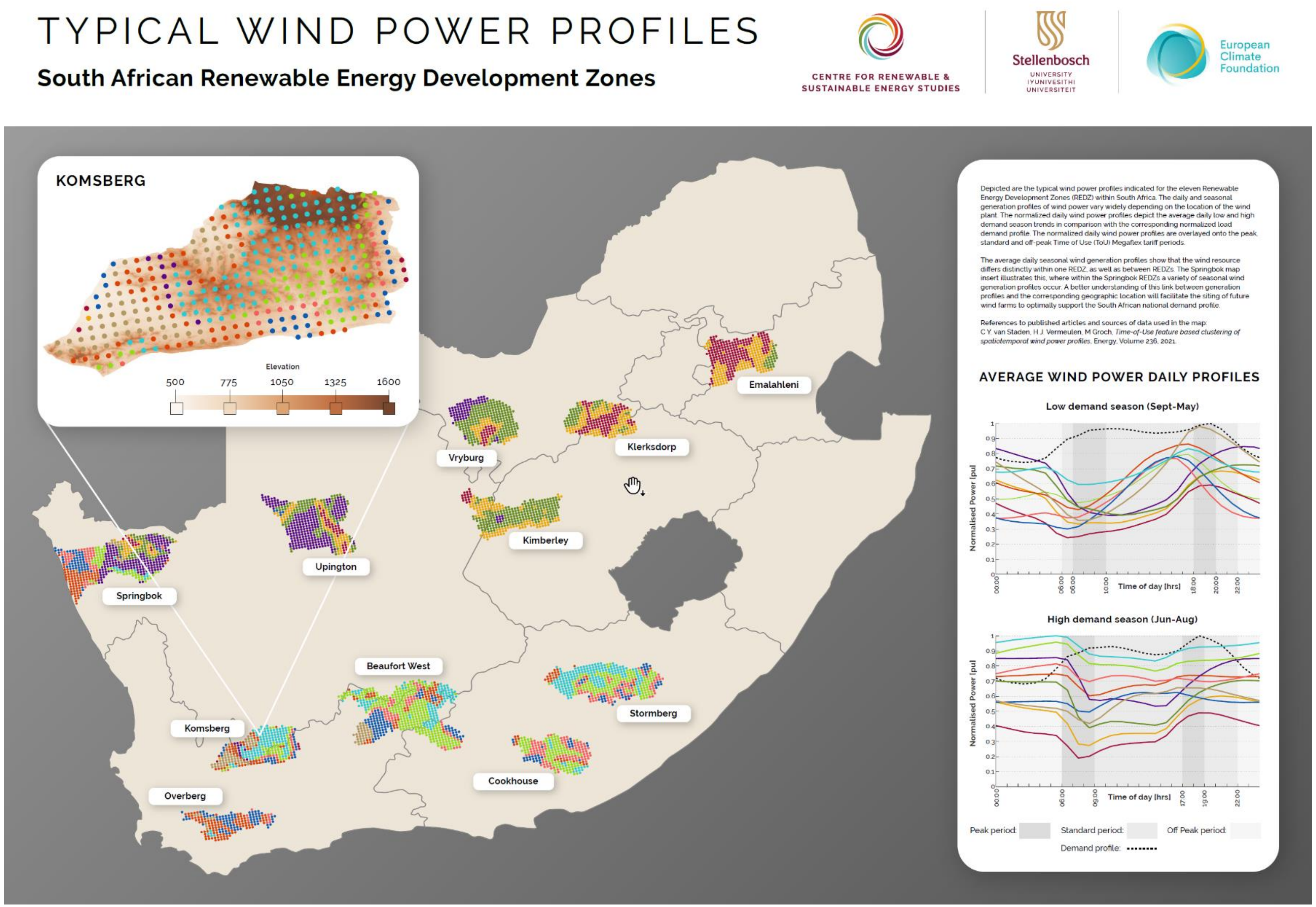
"Where are the best locations in South Africa to site future renewable energy plants to optimally support the grid and maximise social beneficiation, and how to incentivise such optimal siting?"




- Vermeulen et al 2022

# Some of the questions we are addressing
## in support of optimal power system planning and operations

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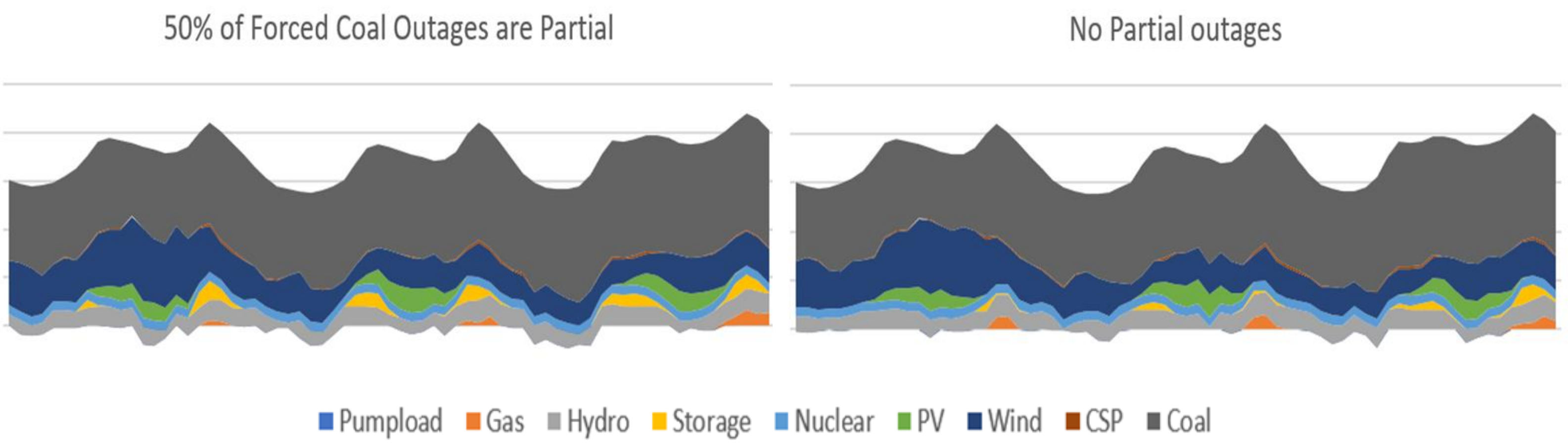
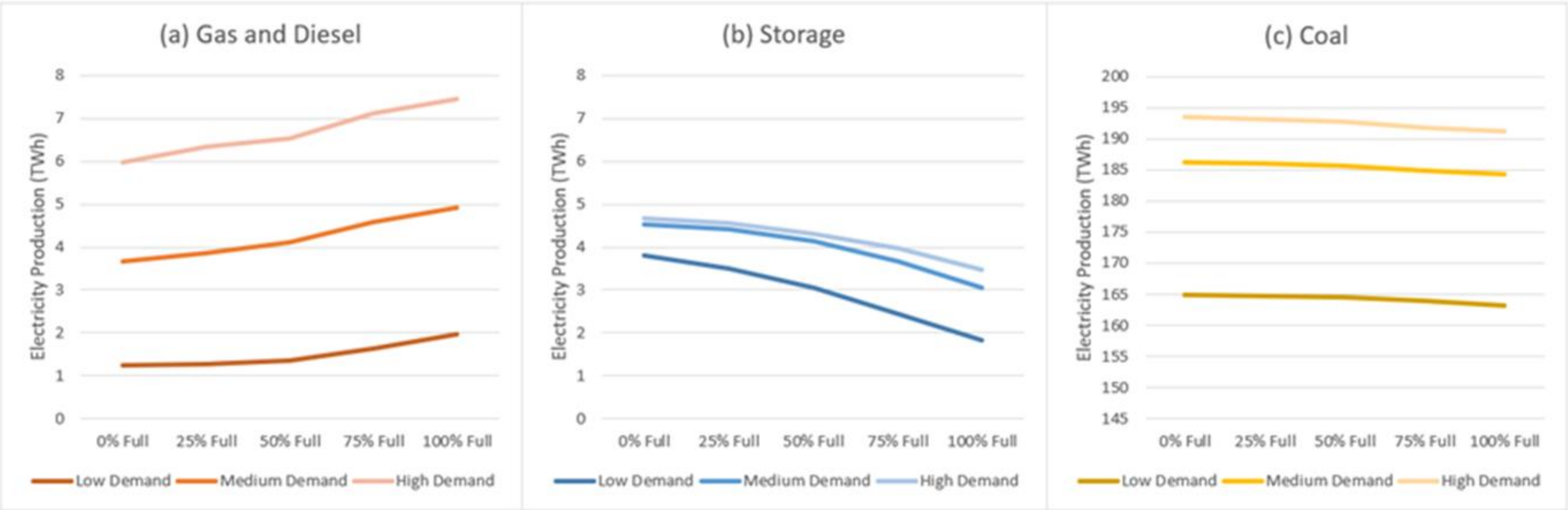
“What is the impact on long term capacity planning model outputs, specifically related to future gas use and energy storage utilization, of incorrect assumptions regarding the types of failures to be expected from South Africa’s aging coal-fired power stations?”




- Auret & Bekker, 2023

# Some of the questions we are addressing
## in support of optimal power system planning and operations

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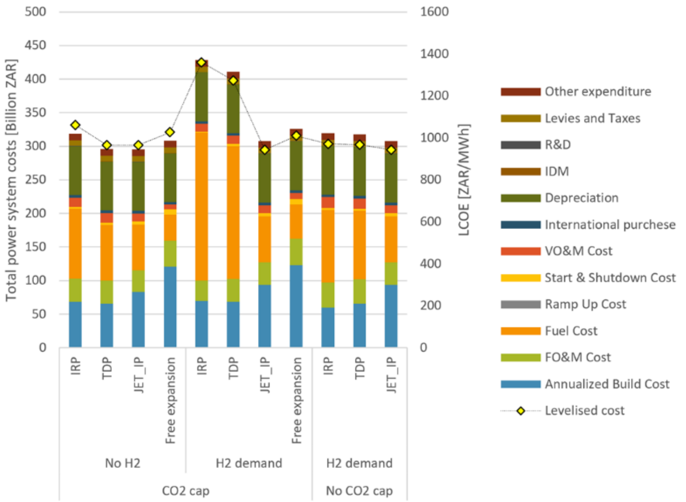
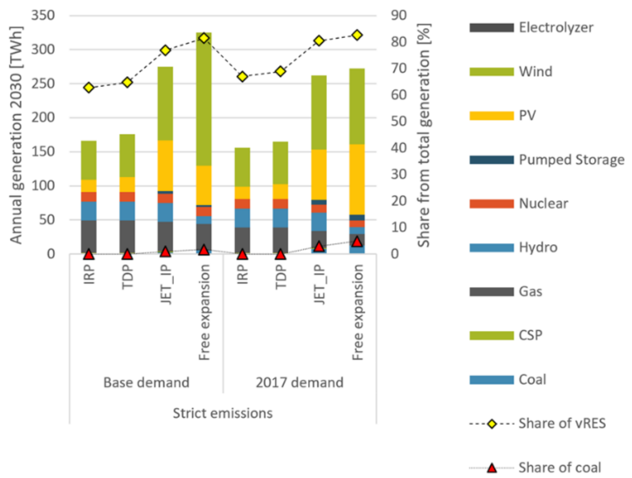
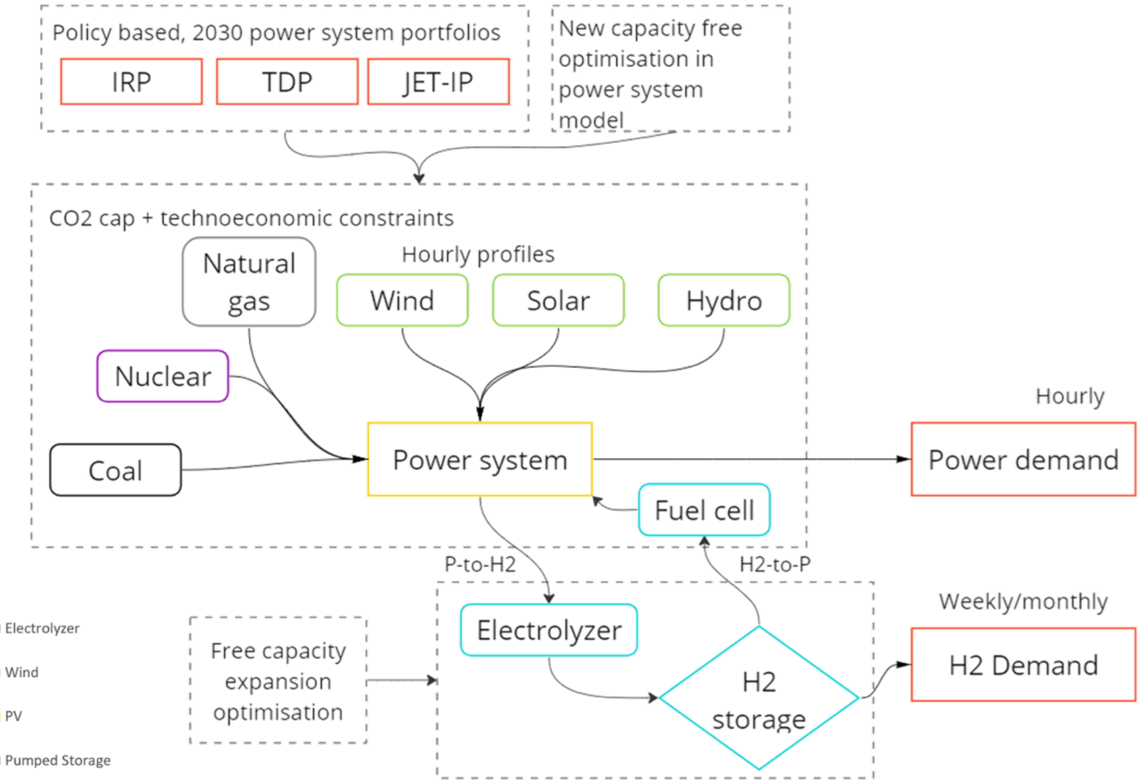
"What are the prospects of grid-connected hydrogen production in a coal-dominated system like SA by 2030, in terms of unserved energy, curtailment, emissions, LCOE, LCOH, and "green" status?"

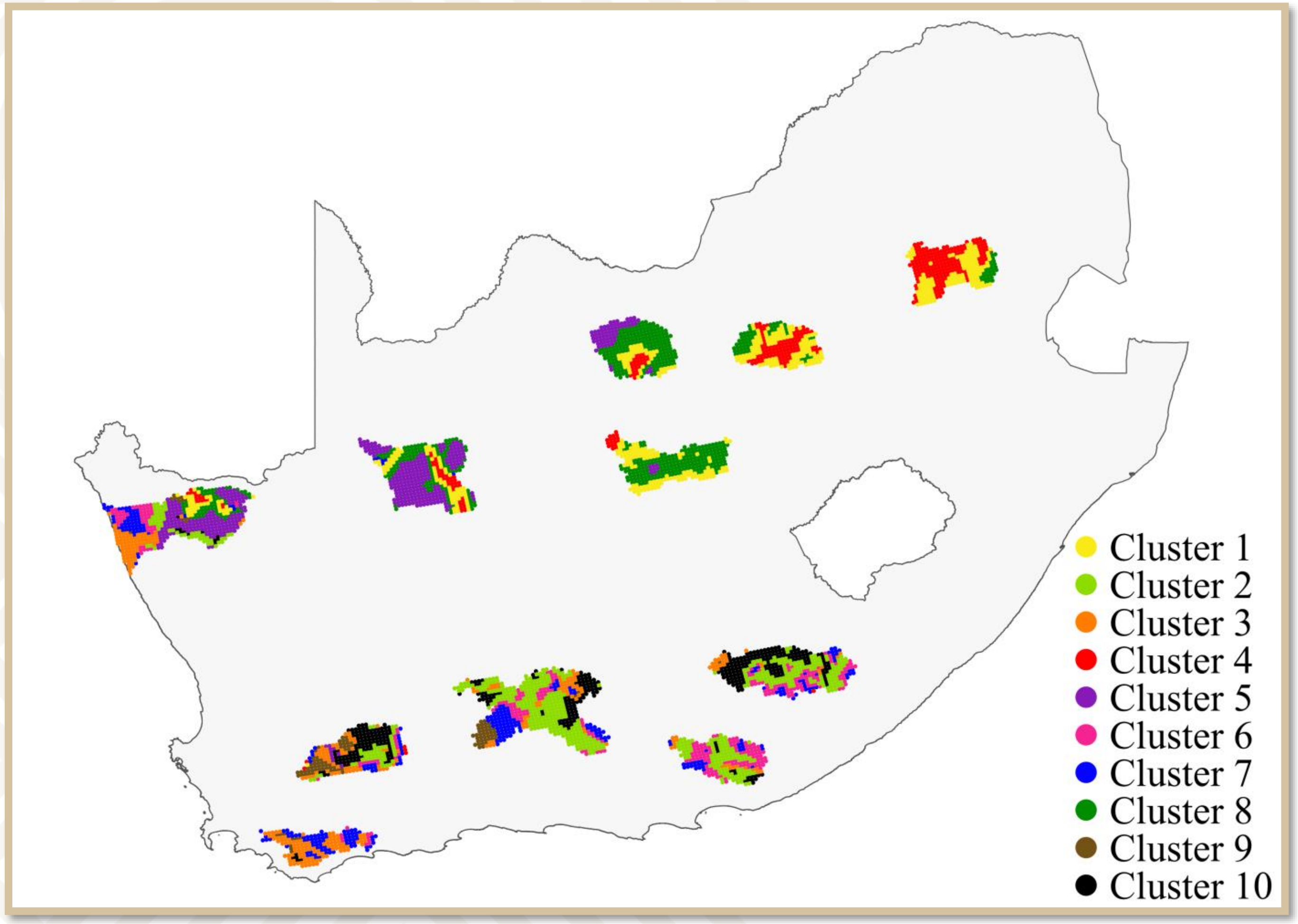


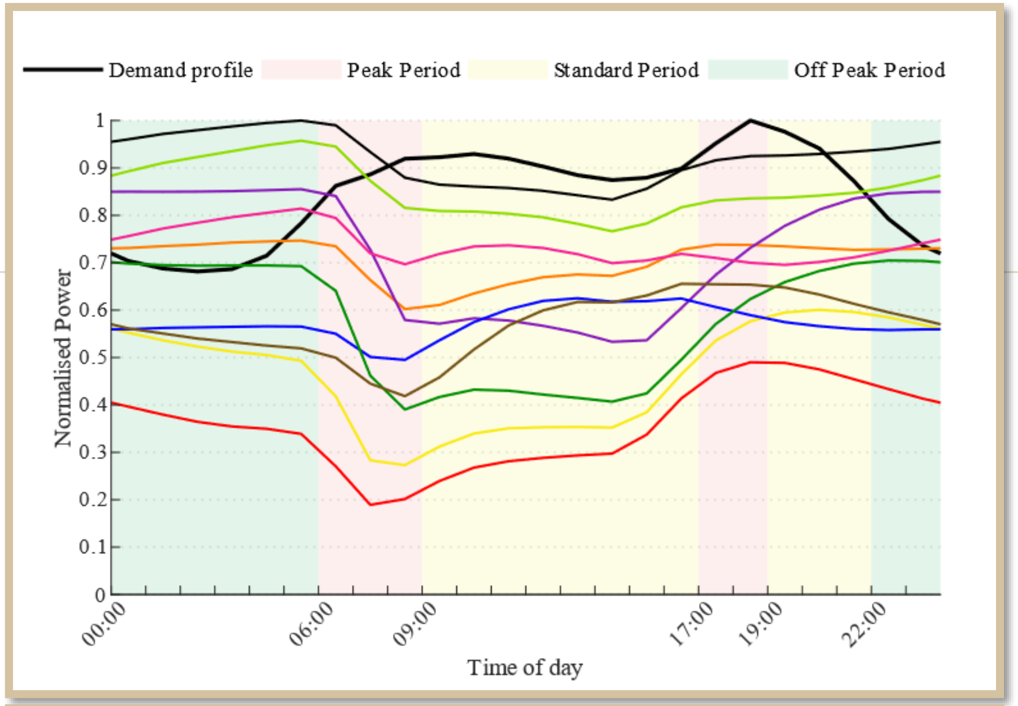



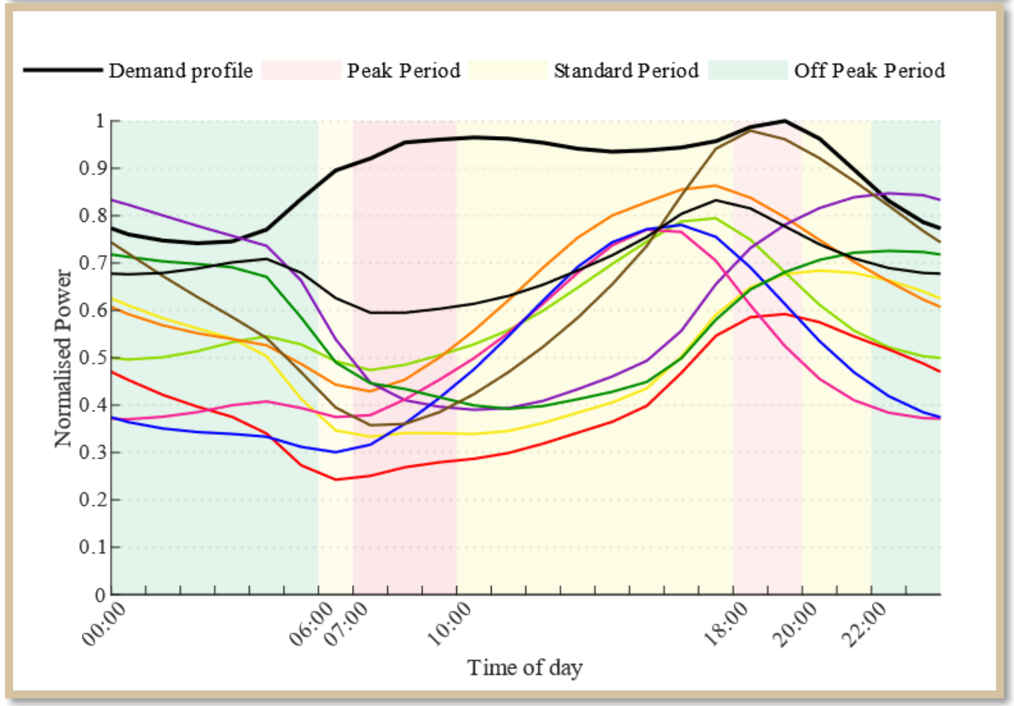



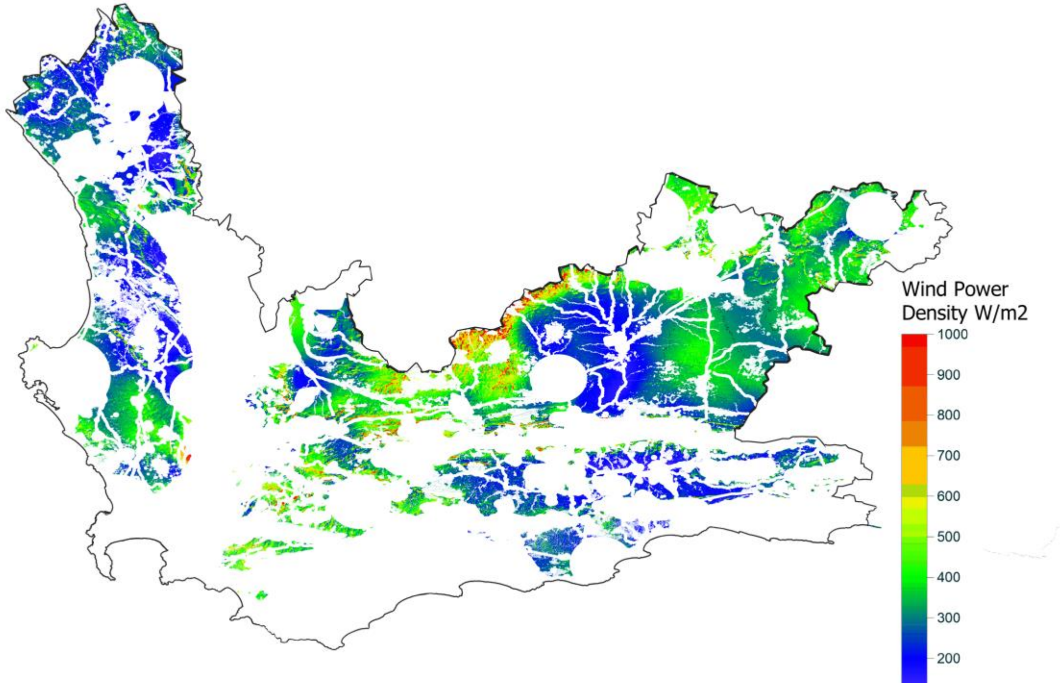

- DRAFT RESULTS – PLEASE DO NOT DISTRIBUTE - Beres et al 2023

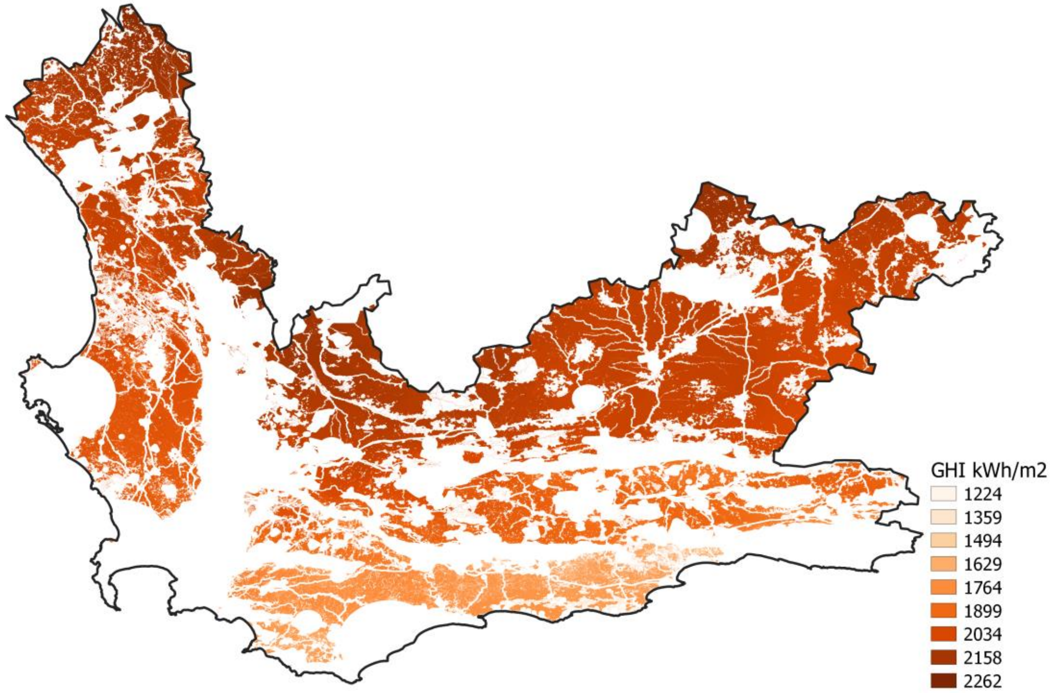
# CLASSIFICATION OF WIND RESOURCES

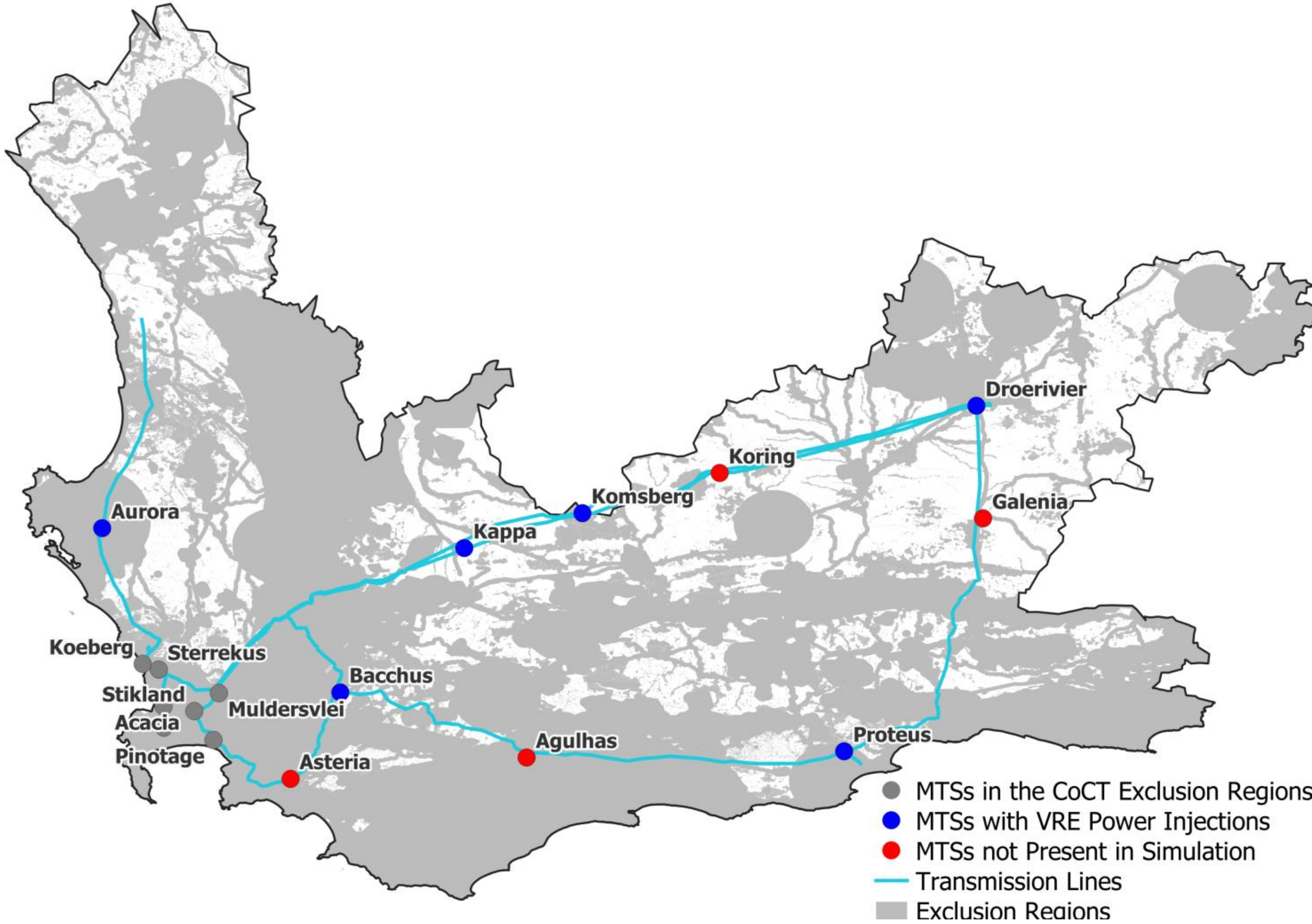


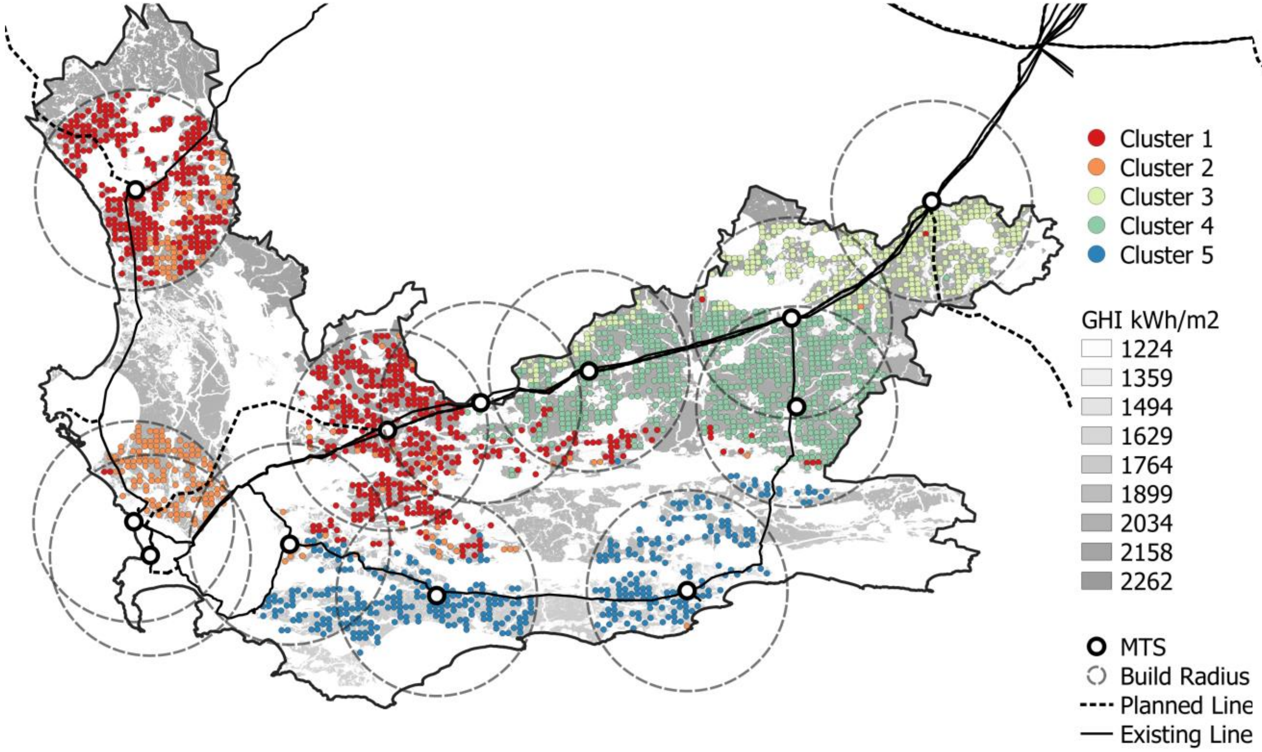

Wind Power Density W/m2
1000
900
800
700
600
500
400
300
200

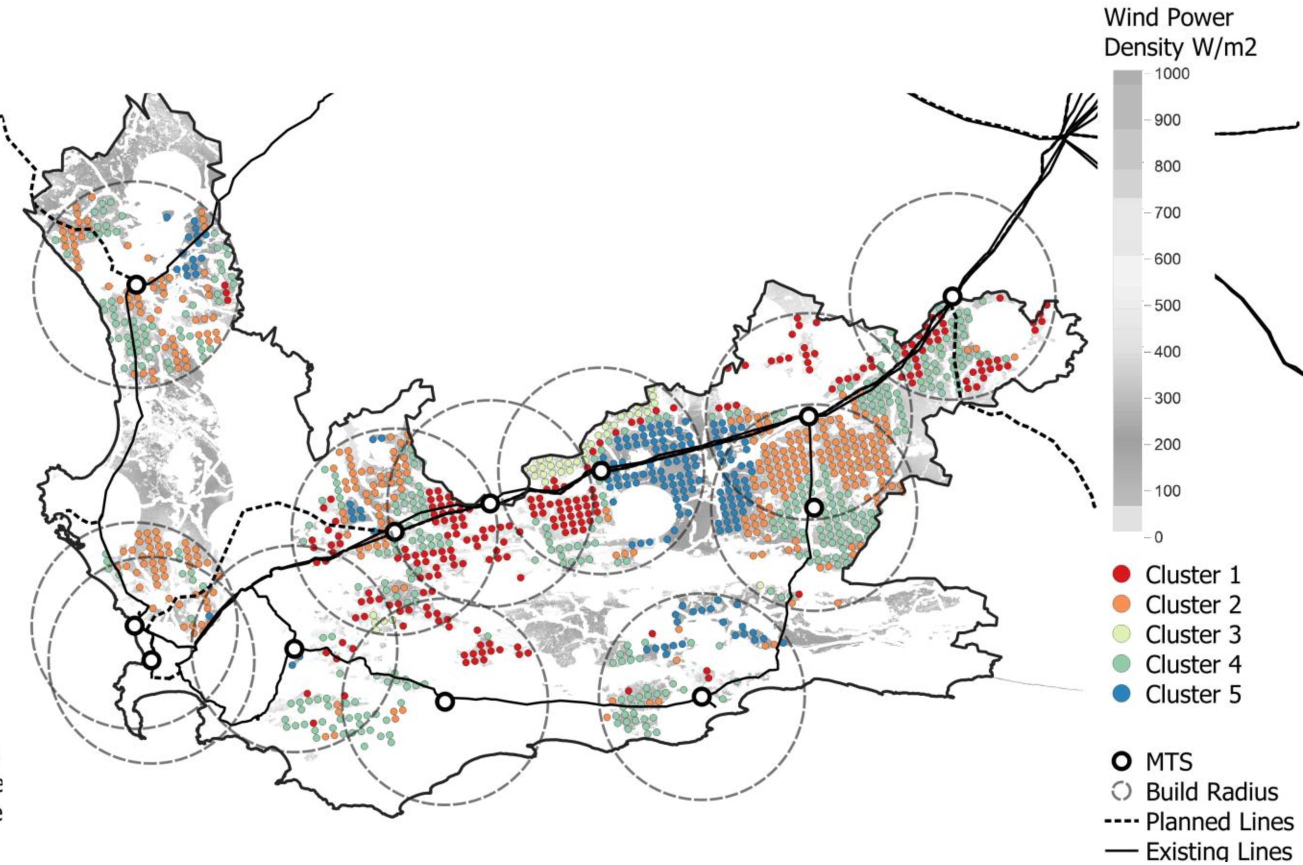

GHI kWh/m2
1224
1359
1494
1629
1764
1899
2034
2158
2262


Droerivier
Koring
Galenia
Komsberg
Kappa
Aurora
Koeberg
Sterrekus
Bacchus
Stikland
Muldersvlei
Acacia
Pinotage
Asteria
Agulhas
Proteus
MTSs in the CoCT Exclusion Regions
MTSs with VRE Power Injections
MTSs not Present in Simulation
Transmission Lines
Exclusion Regions

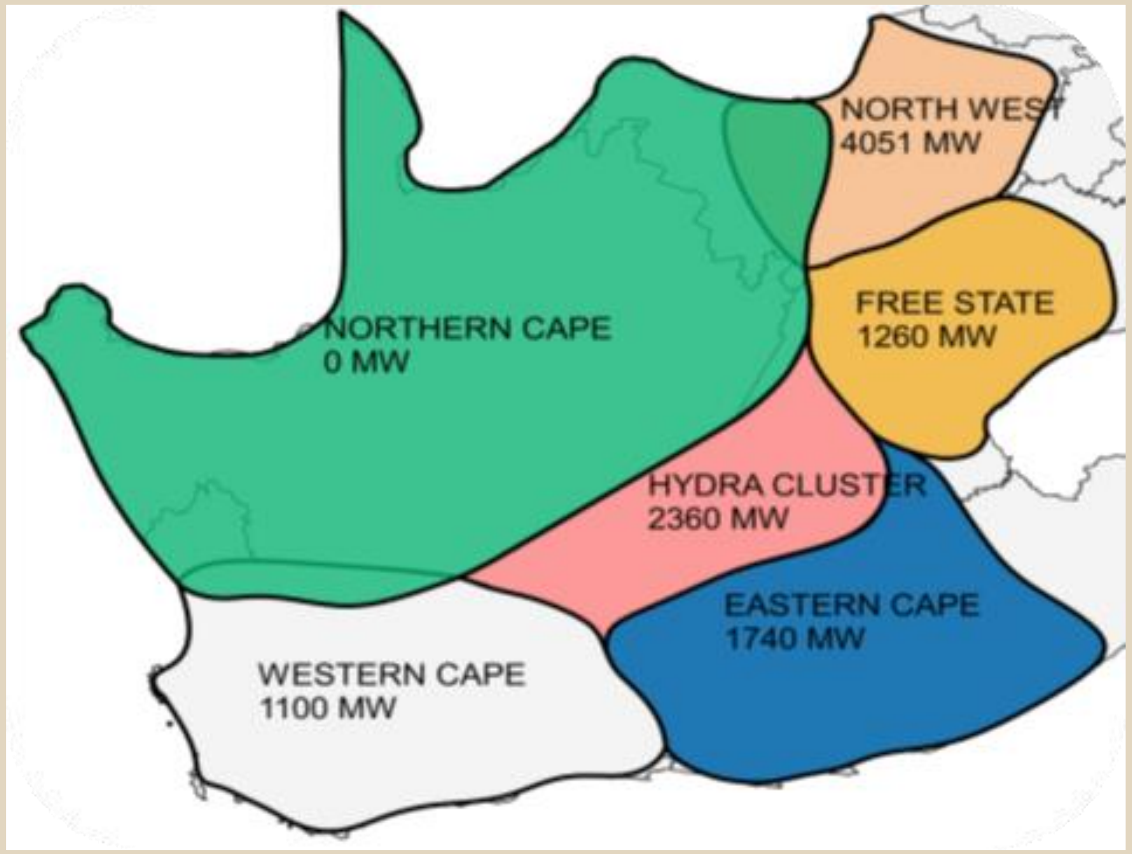
# CLASSIFICATION OF RE RESOURCES

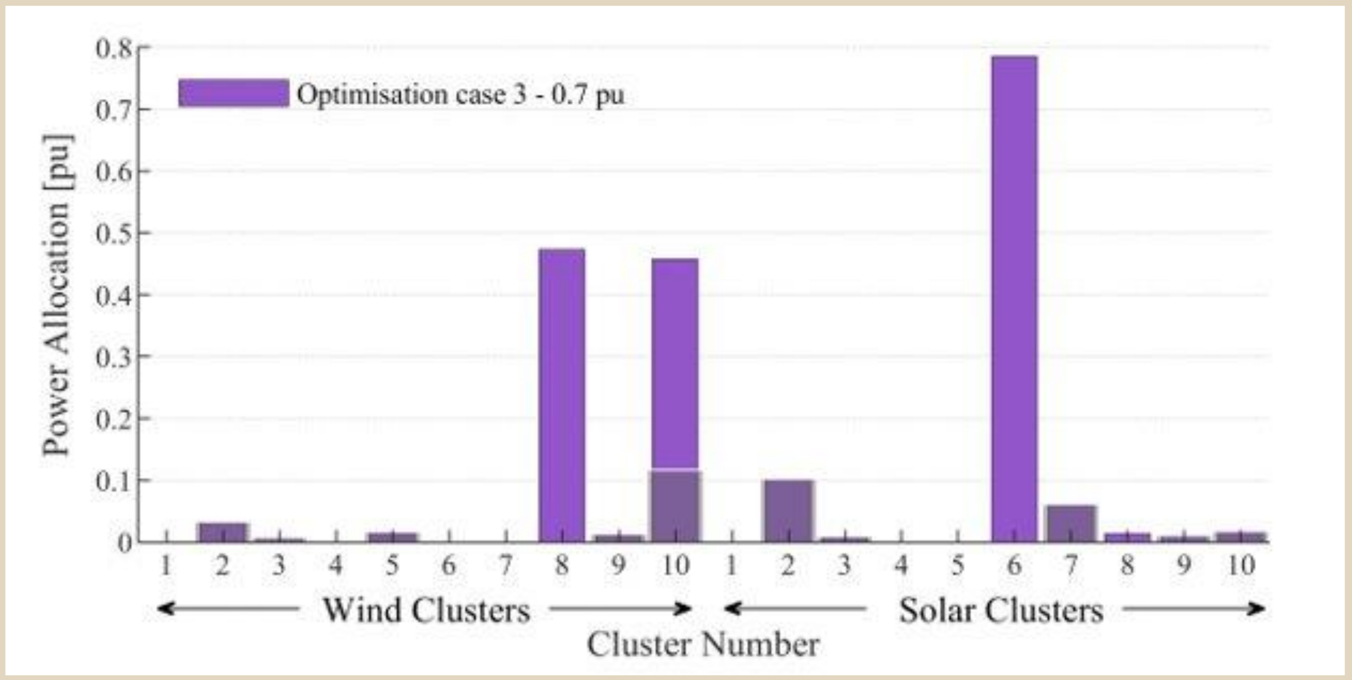




# OPTIMAL ALLOCATION OF VARIABLE RENEWABLE RESOURCES



# THE IMPACT OF CLIMATE CHANGE ON RENEWABLE RESOURCES



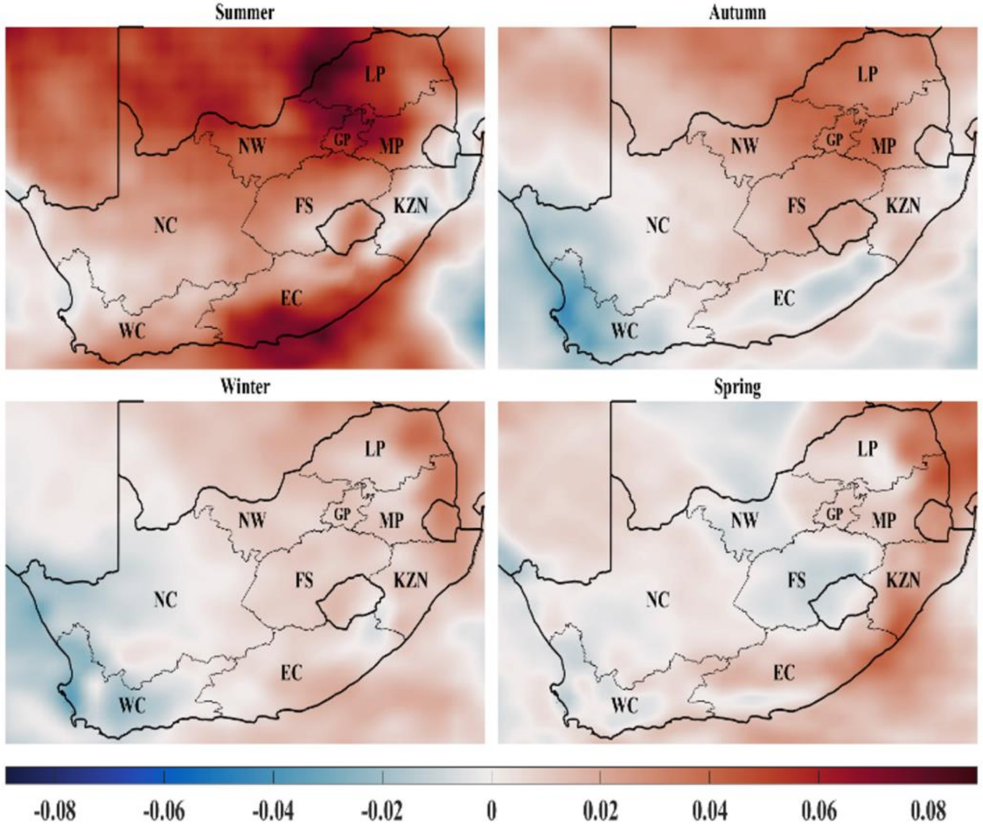
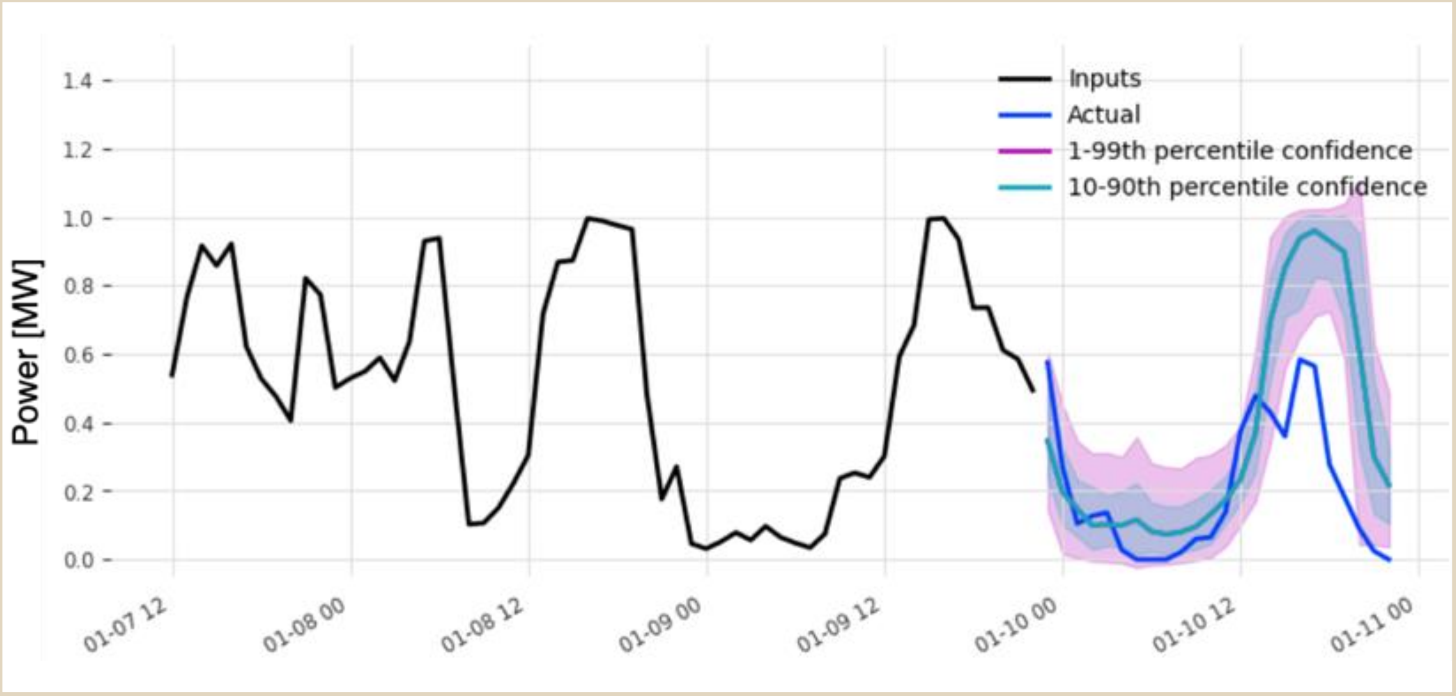


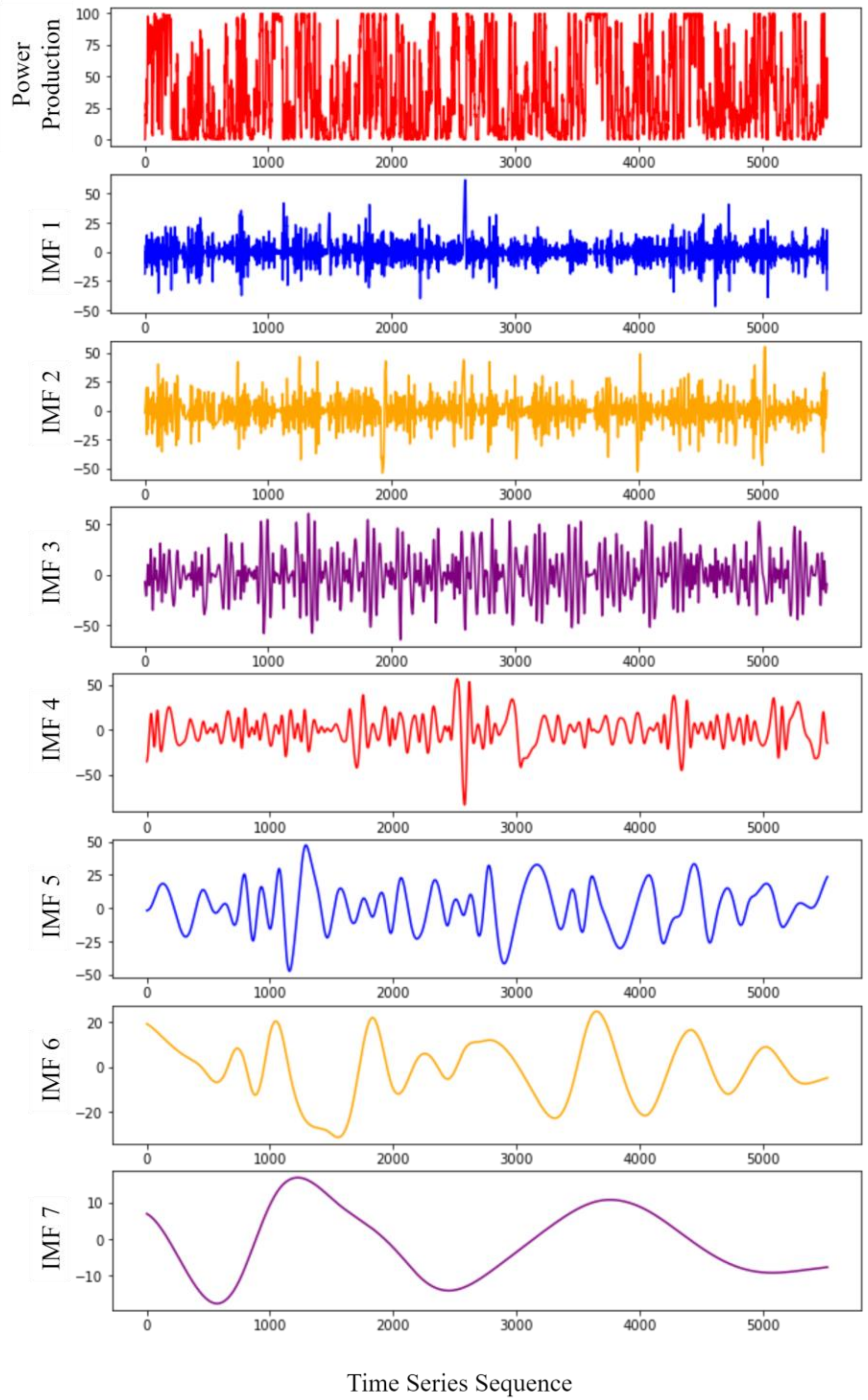

Fig.11. Percentage trend in COV over the 70-year period spanning 1951-2020, *(%/season)*

- Looking at the VRE capacity and variability of South Africa historically
- What is the predicted impact in the future?

# FORECASTING OF WIND GENERATION

Using Hybrid Recurrent Neural Networks with Empirical Mode Decomposition and Temporal Fusion Transformer



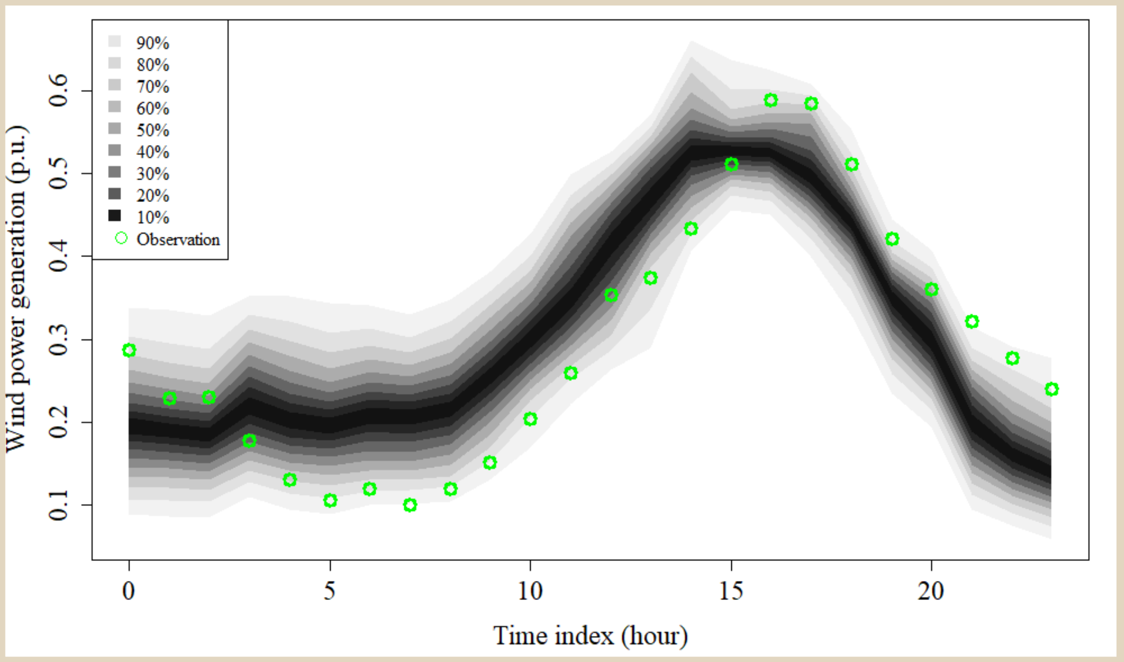



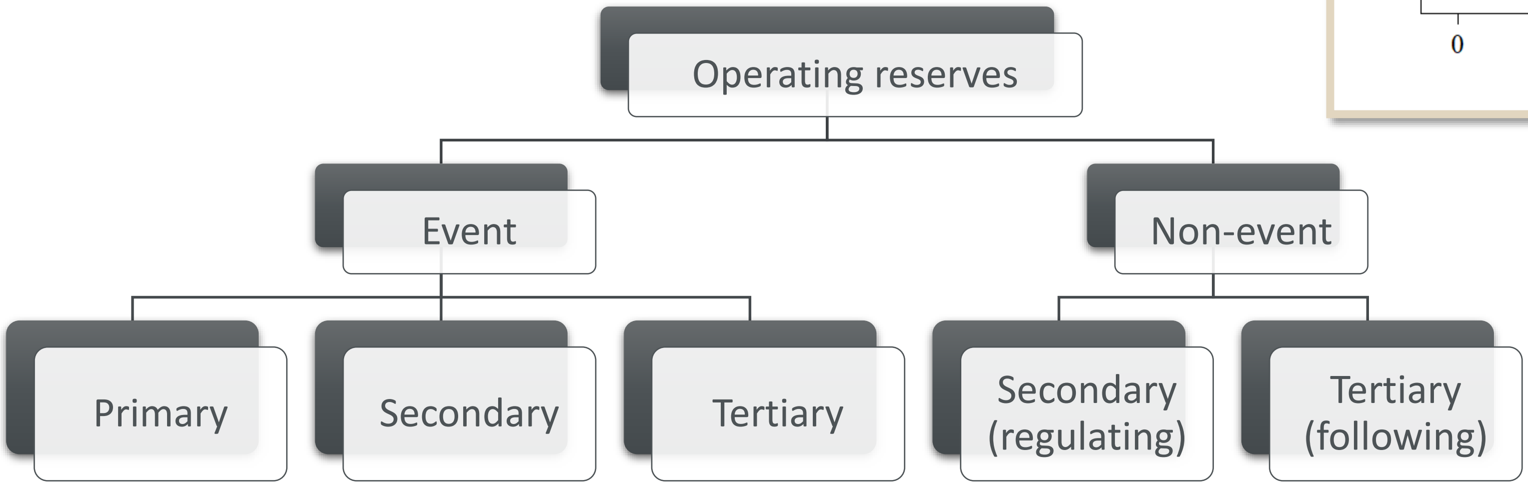
# POWER SYSTEM OPERATIONS



Improving:

- Unit commitment
- Scheduling
- Reserve allocation methodologies



# DIVERSIFY ENERGY-MIX FOR GREEN HYDROGEN PRODUCTION

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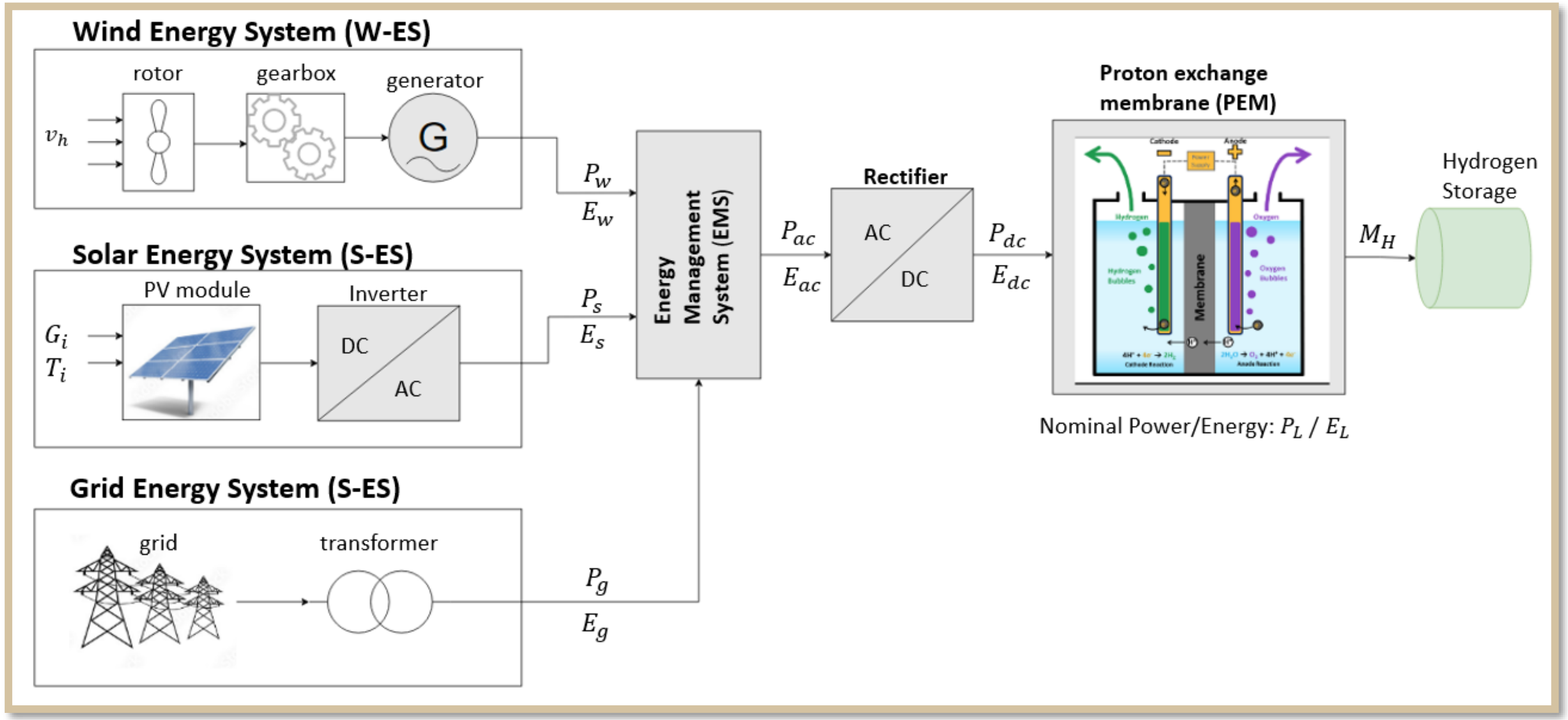
- Maximize reliability of the energy system
- Minimize cost of electricity usage for hydrogen production
- Maximize efficiency of the energy system




With the use of modelling and optimization techniques

# OPTIMIZING ELECTRICAL INFRASTRUCTURE FOR GREEN HYDROGEN PRODUCTION UNITS IN SA

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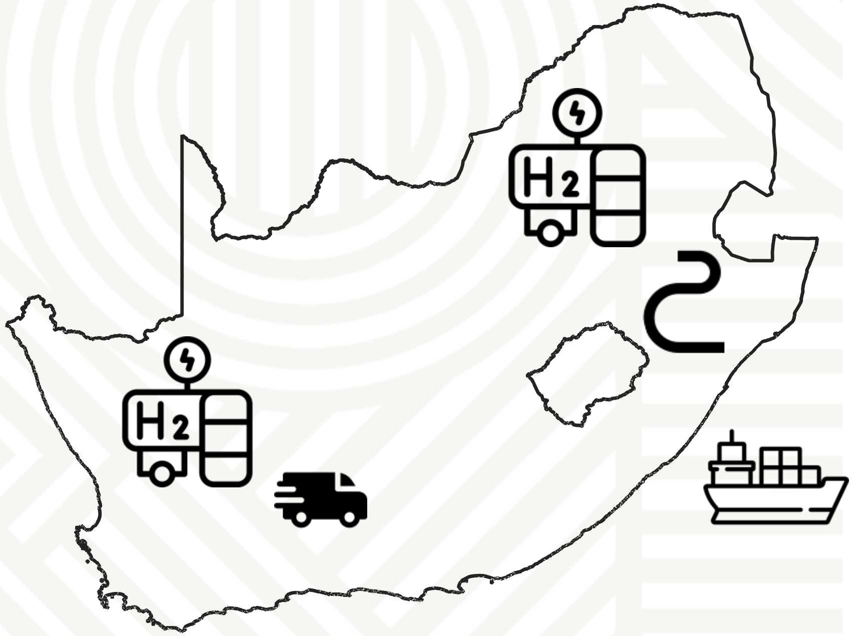


- Determining ideal locations for green hydrogen plants
- Development of a framework to aid in informed decision-making pertaining to local and international green hydrogen investment.

Key study areas

- Logistics around the transportation of green hydrogen
- Cost, efficiency, and safety analysis for the entire value chain

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