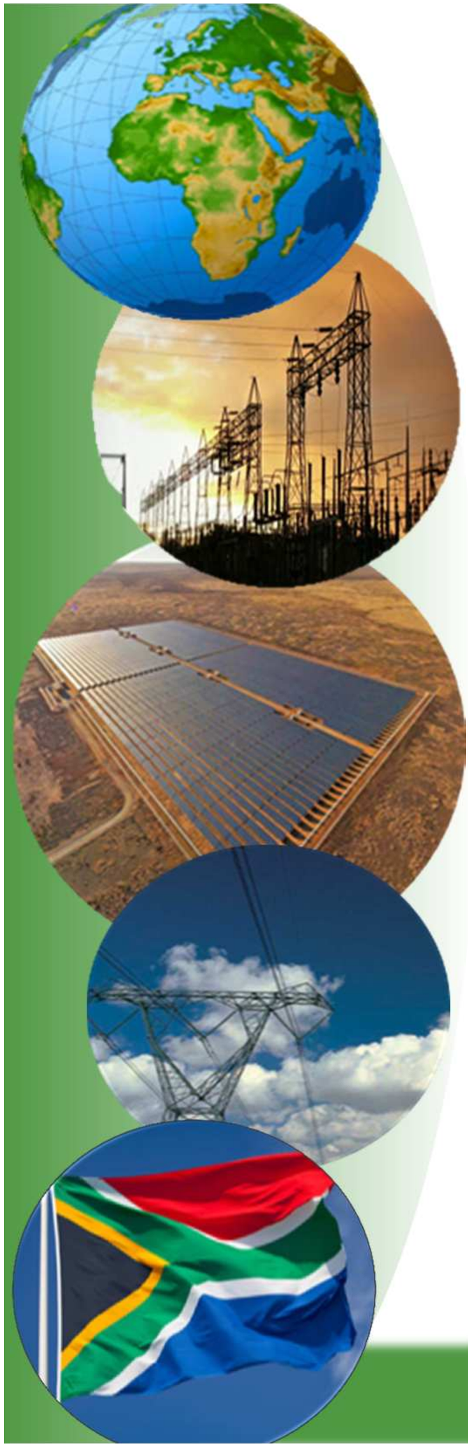

Strategic Plan for Integrating Future Renewable Energy Generators in South Africa

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Presentation Overview

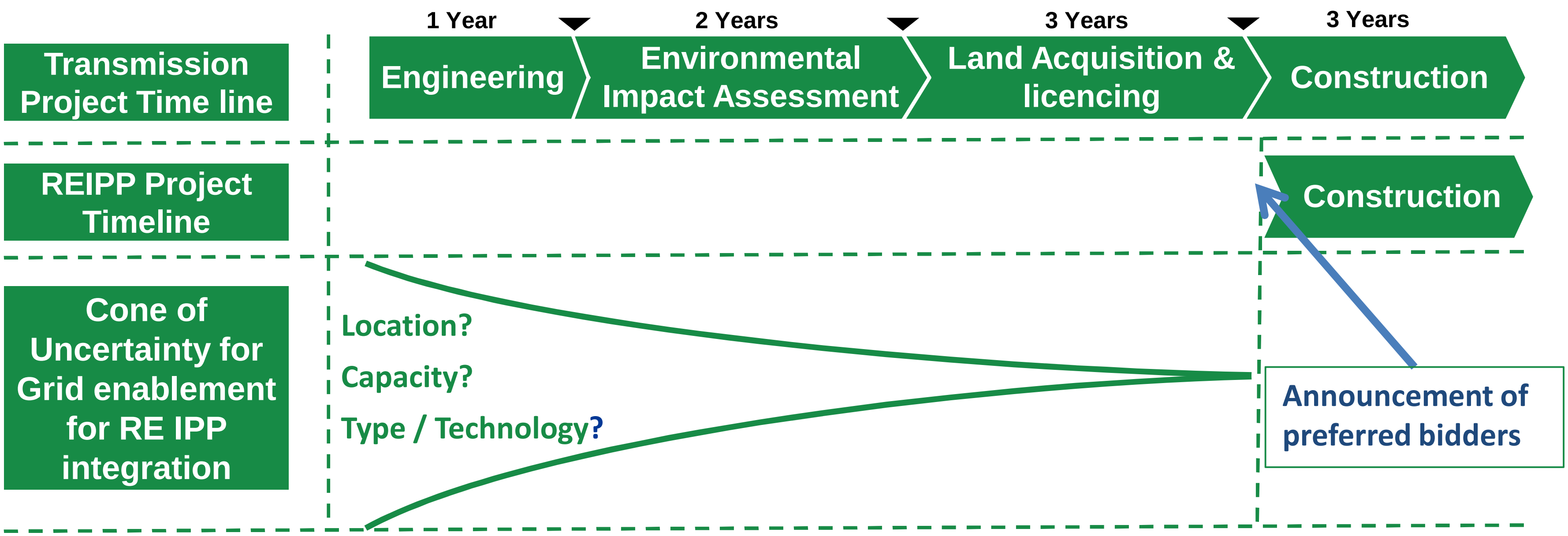
- Introduction and Background
- Problem Statement
- Approach
- Assumptions
- Network Studies
  - Transmission & Sub-transmission Studies (Local level)
  - Transmission Studies (Global level)
- Findings of the study
- Conclusion and Recommendations

Introduction and Background

- In 2010, South Africa embarked on a process to diversify its energy sources by introducing renewable energy (RE) as part of the energy mix.
- Following the IRP 2010, a Draft IRP was released in December 2016, which shows ambitions to integrate substantial RE generation in the country up to 2050 with the REIPPPP as an implementation vehicle.
- The IRP only specifies the quantity and technology to be connected without prescribing geographical location. This presents spatial uncertainty and difficulty in formulating associated grid connection plans.
- This paper presents a South African case on strategic planning using the least-regret approach to effectively deal with RE spatial dispersion and capacity challenges

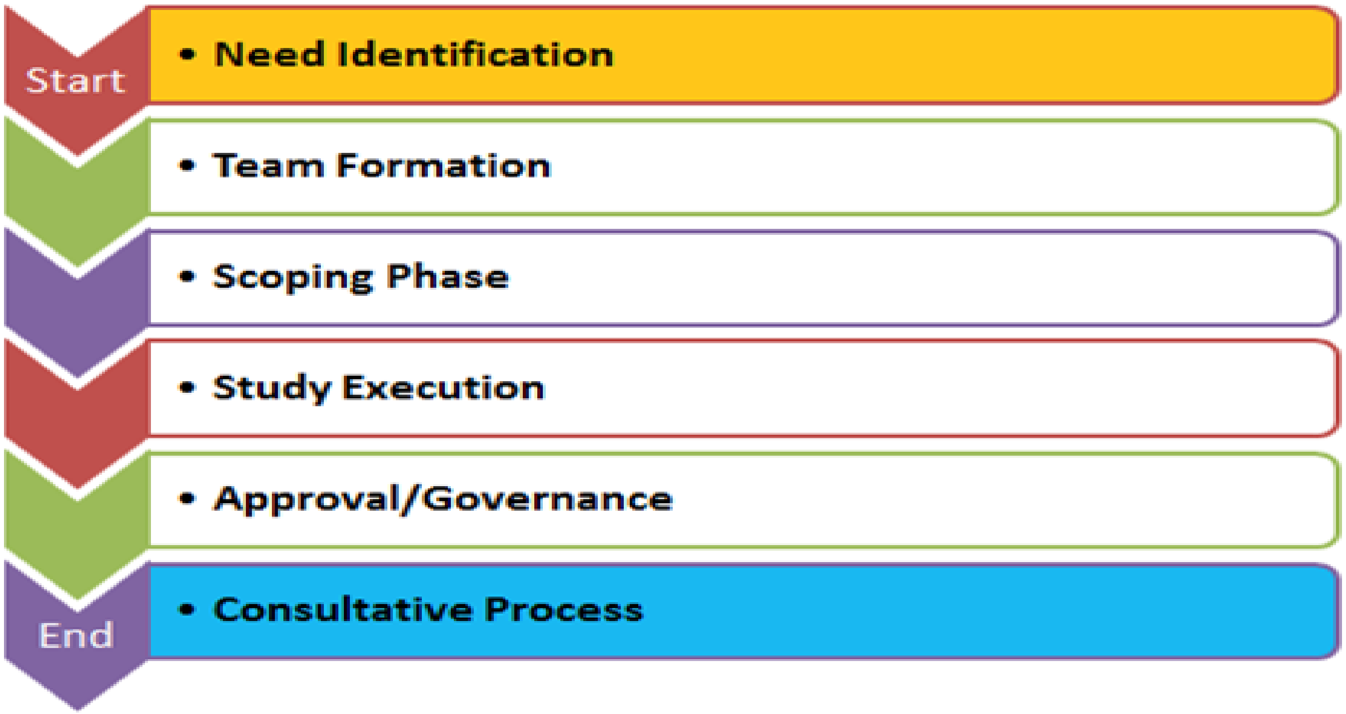
Problem statement

- The initial rounds (up to 4B) of the REIPPP programme have consumed much of the available connection capacity on the national grid; hence an urgent need to create additional capacity for the future IPP programmes
- Other challenges pertaining the enablement future RE programs are as follows:
  - Sub-optimal network design and deployment of resources
  - Spatial disparity between load centres and RE generation areas
  - Plans can only be finalised upon announcement of preferred bidders
  - Longer lead times for network development compared to RE plant development



Approach (Framework)

- A framework favoring the long term transmission and distribution network development to facilitate the integration of generation from RE resources was adopted.
- An overall approach guiding the process was both deterministic (i.e. decided upfront) and emergent (i.e. certain elements were deemed necessary during the study), as per diagram.

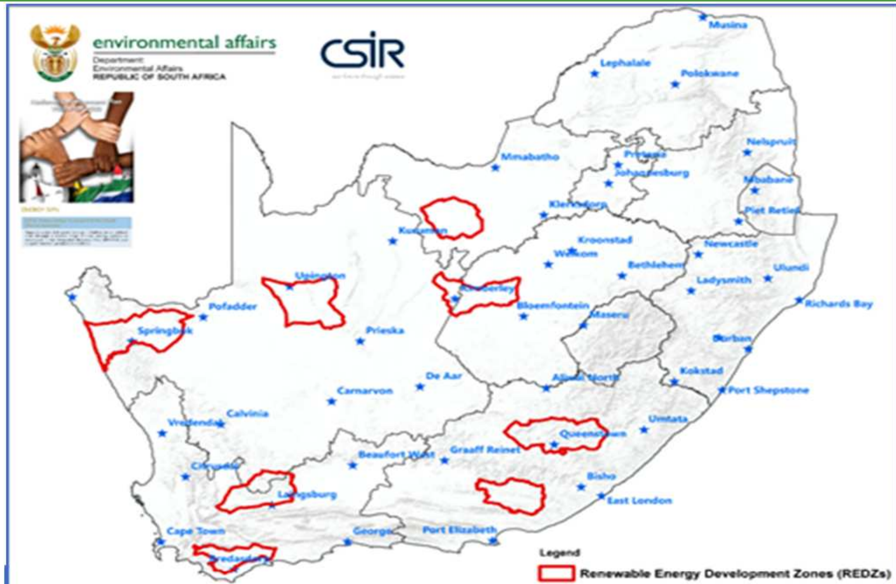


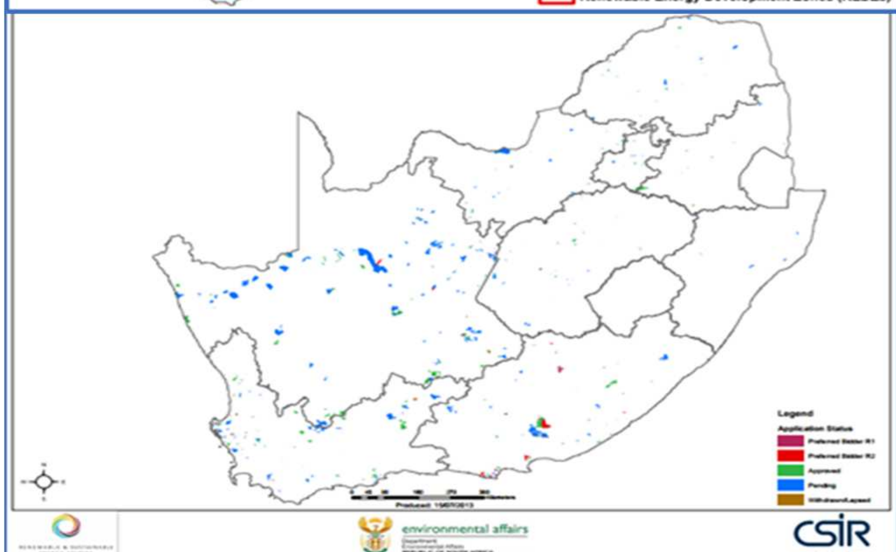
Approach (Study execution)

Stakeholders	Activity
All stakeholders	Adoption of the Plan (consultative with industry stakeholders)
Transmission & Distribution	Governance Approval (internal Approvals)
Transmission & Distribution	Consolidation of studies (Iterative Process) • Review and alignment
Transmission	Transmission integration studies (Global level) • Capacity factor calculation & Load Balancing • Corridor Sizing
Distribution & Distribution	Sub-transmission & Transmission studies (Local level) • Installed capacity based • Connection infrastructure requirements assessment
All stakeholders	Formulation and adoption of assumptions • ICE Applications database since REIPPPP inception • Prospective REIPP EIA EA database

Transmission and Distribution Network Codes

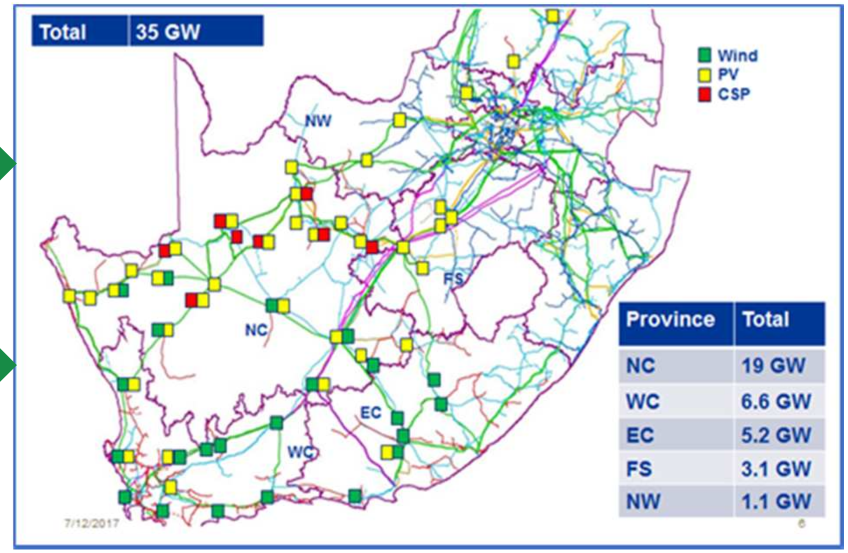
Assumptions





Location and Volume (multiple sources):

- Connection Requests From IPPs
- IPP EIA applications
- REDZ Research

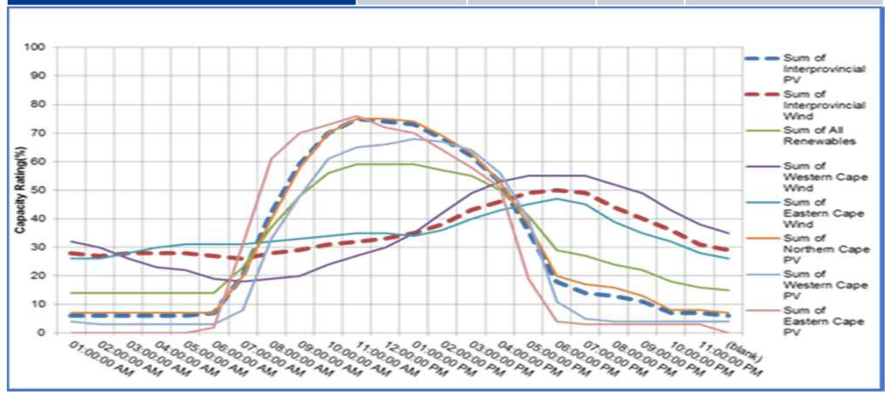


Assumptions - Transmission Corridor

Determination of Capacity Factors

- RE is intermittent, which yields diversity between geographical areas.
- Power flow scenarios were formulated based on the generally accepted practice (midday, peak load, and light load scenarios) as per table
- Metered data verification showed that assumptions were within reasonable range as shown in graph.

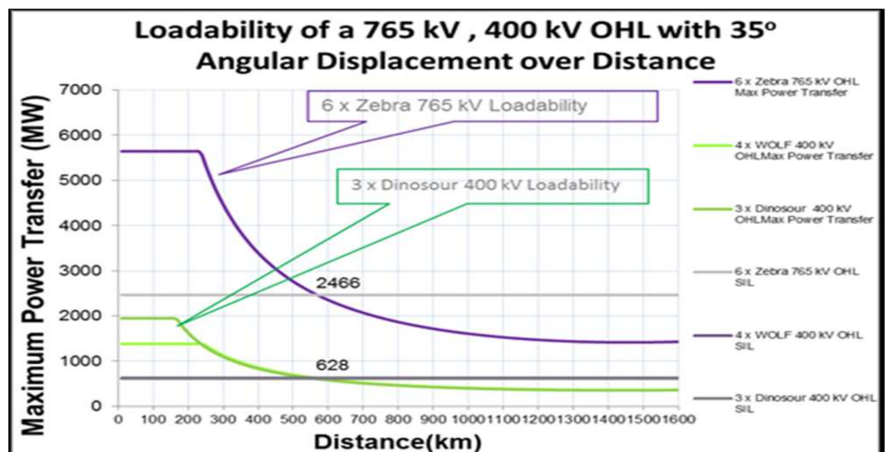
CSP	PV	CSP	WIND	Load
1. Midday RES generation	100%	100%	30%	75 % TOSP Load
2. Time of Daily System Peak RES generation	30%	0%	100%	100% TOSP Load
3. Midnight RES generation	0%	0%	100%	50% TOSP Load



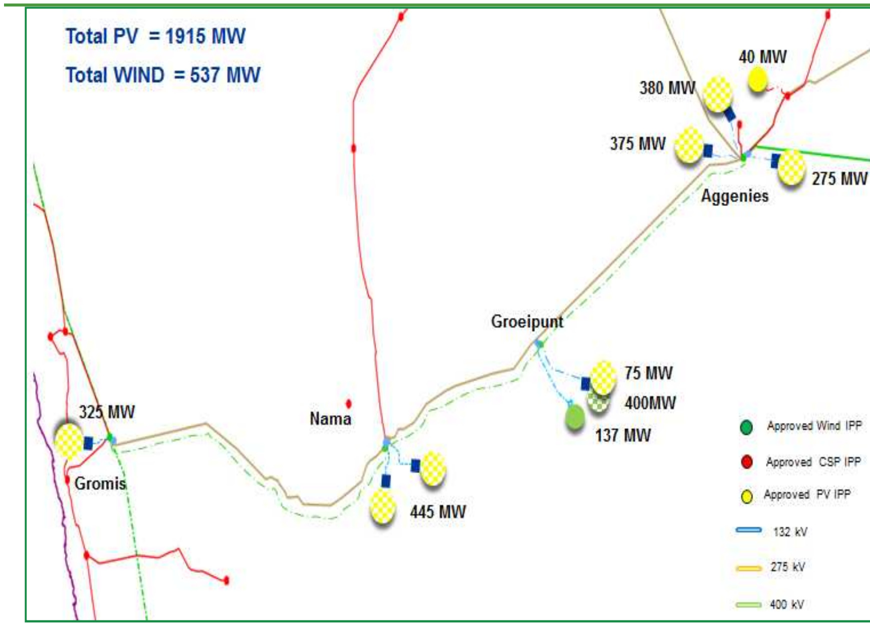
Transmission line loadability

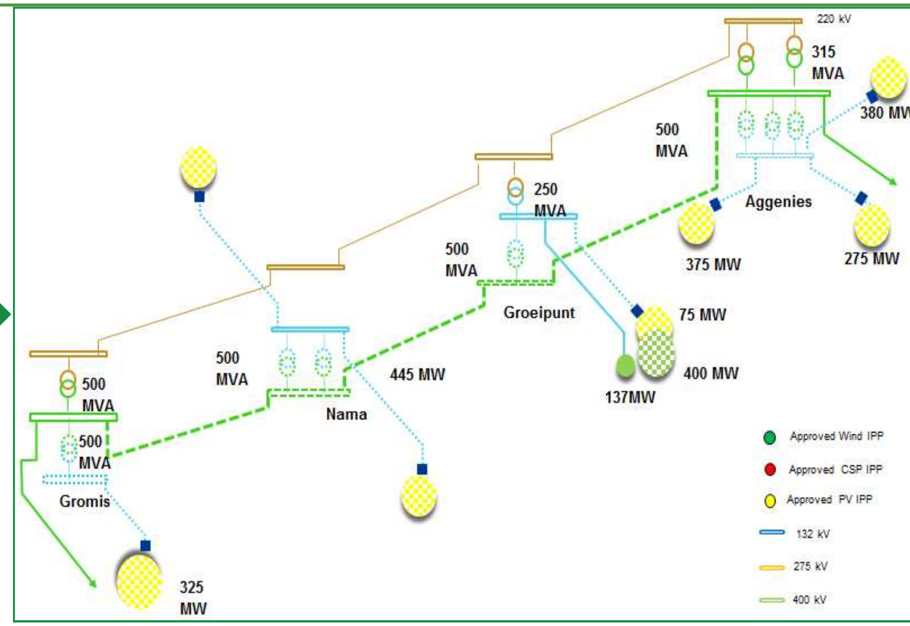
- Corridor sizing was based on line loadability characteristics at angular displacement of 35 degrees

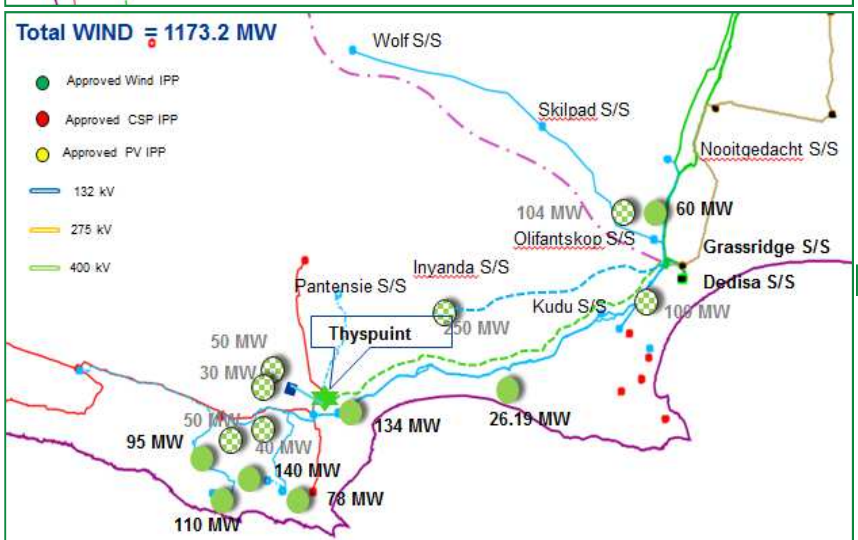
$$P_{max} = (V_{s.p.u})(V_{r.p.u})(SIL)\frac{\sin(\delta)}{\sin\left(360^0 \frac{Length}{\lambda}\right)} = (V_s)(V_r)\frac{\sin(\delta)}{x}$$

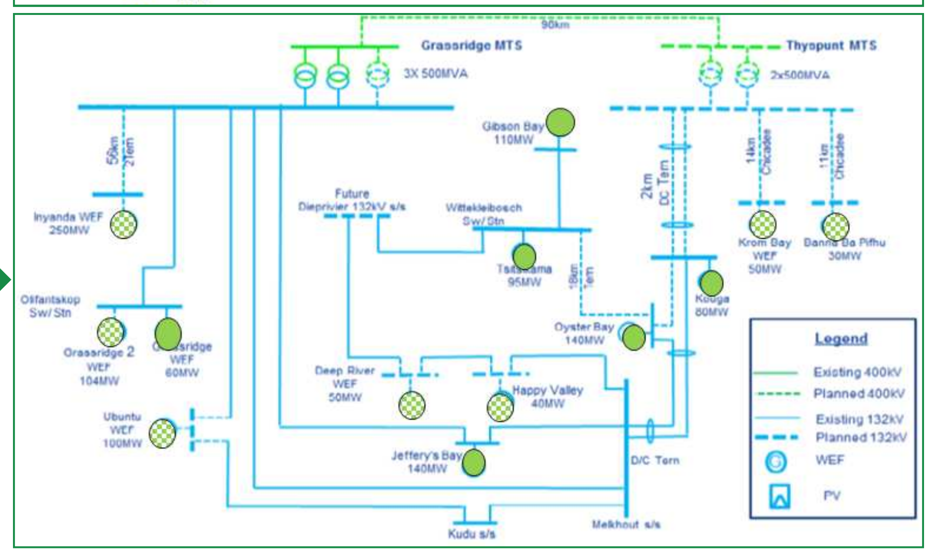


Network Studies (Local level): Illustrations









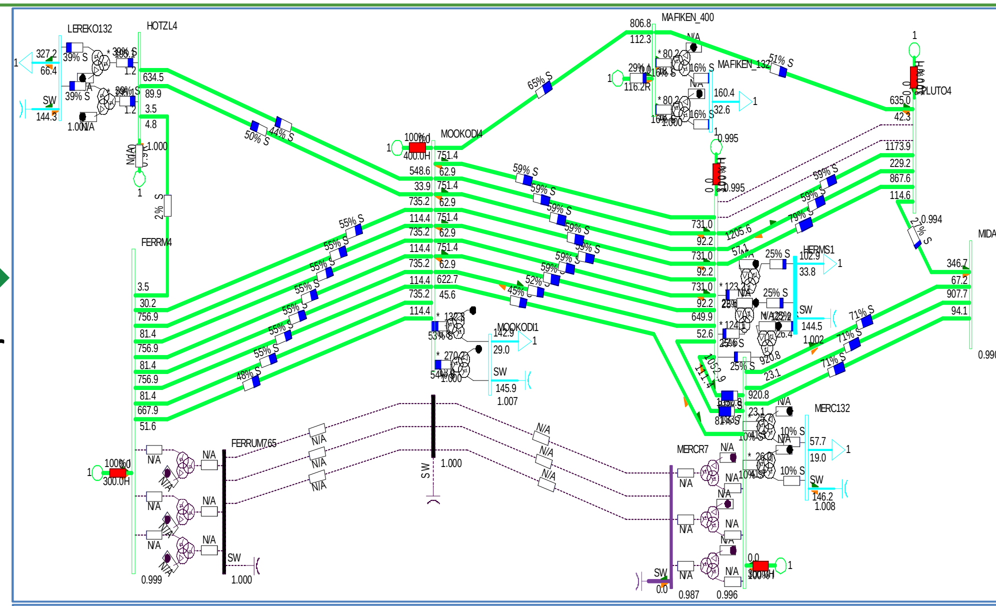
Network Studies (Global level): Illustrations

Transmission

Three Scenario analysis (midday, peak & light)

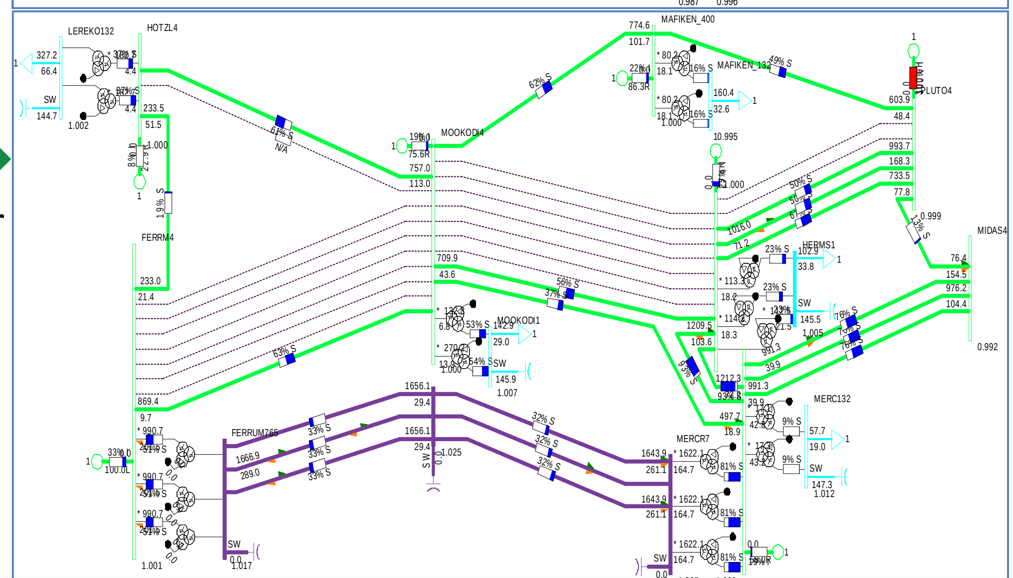
400 kV Power evacuation scenario

- Ten transmission lines required for power evacuation
- Most environmental impact



765 & 400 kV Power evacuation scenario

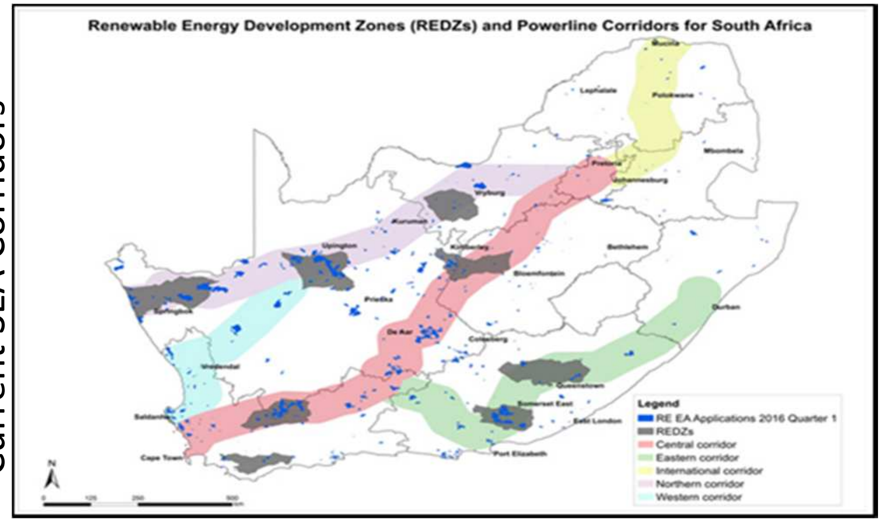
- Five - Six transmission lines required for power evacuation
- Least environmental impact



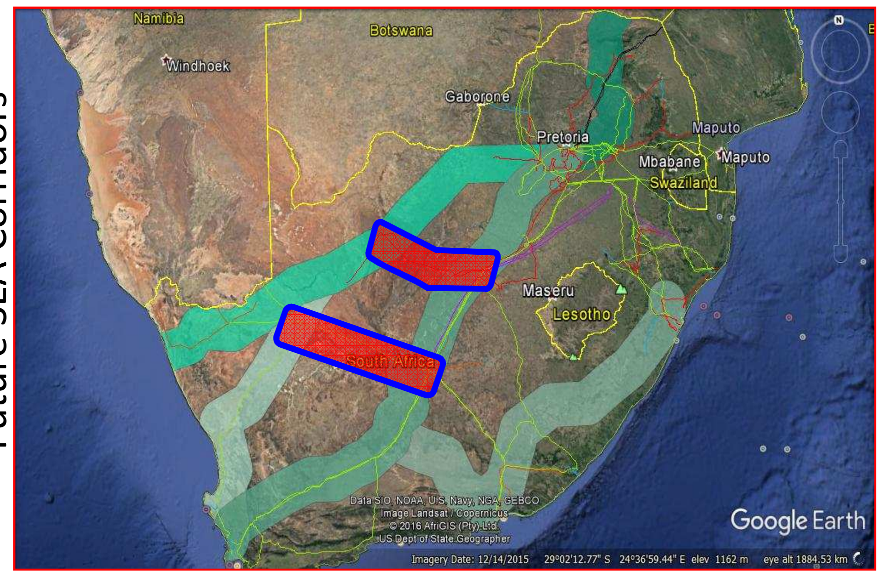
Findings of the study

- Future transmission corridors, transmission substations , distribution lines and distribution substations (collectors & satellites) were identified.
- This yields a “blueprint” on which additional Strategic Environmental Assessments (SEAs) for future distribution and transmission infrastructure will be based.
- This work will enhance process that had already been started by Eskom, CSIR and DEA on SEAs based on a Strategic Grid Plan as shown in graph

Current SEA Corridors



Future SEA Corridors



Conclusions and Recommendations

The following recommendations were made:

- Development trigger points: It was evident that geographical areas require varying degrees of grid development. It is better for the industry to systematically develop in blocks of developmental phases, with infrastructure investment triggered at each bid-window, and the developmental phases, ranked according to the overall cost to the economy

- To enable expeditious rollout of infrastructure, certain strategic activities need to take place in advance; these include EIAs, acquisitions and concept designs. It is recommended that funding be approved for these strategic initiatives.

- To optimally implement the strategic plan, various stakeholders such as DoE's IPP Office, Eskom, IPPs, NERSA, and other parties need to be aligned.

- The blueprint emanating from this plan should be used for future infrastructure development plans and IRP's.