Energy future of freight and passenger rail in South Africa

Feasibility Study

Stellenbosch University Iyunivesithi Universiteit
Engineering EyobuNjineli Ingenieurswese

AIH ECONOGISTICS

20 November 2024

PRESENTATION OVERVIEW

AIH GROUP

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ebp MANAGEMENT south africa

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PAC THE PAC GROUP SOUTH AFRICA

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AIH ECONOGISTICS

AIH Econogistics specialises in **economic, sector and cluster development** projects

- Concept development and feasibility
- Socio-economic assessments
- Corridor development and regional integration
- Bankability studies and business cases
- Institutional set-up and governance
- Market studies and competitive analysis
- Project Implementation & management
- Economic development policies and strategies
- Project financing, investment & incentives

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What is the energy future of rail freight and passenger transportation in South Africa?

- **Highlight theme: Sustainable transport**
  - *2030 Agenda for Sustainable Development*
  - *UN Framework Convention on Climate Change (UNFCCC)*
  - *SDG 11: "Make human settlements inclusive, safe, resilient & sustainable".*

- **KEY to sustainable transport: Rail-based, high-volume public transport and freight systems**

- **Alternative renewable energy sources for rail could**
  - *Improve rail's energy efficiency*
  - *Reduce GHG emissions*
  - *Reduce reliance on electrical power from overhead catenary*

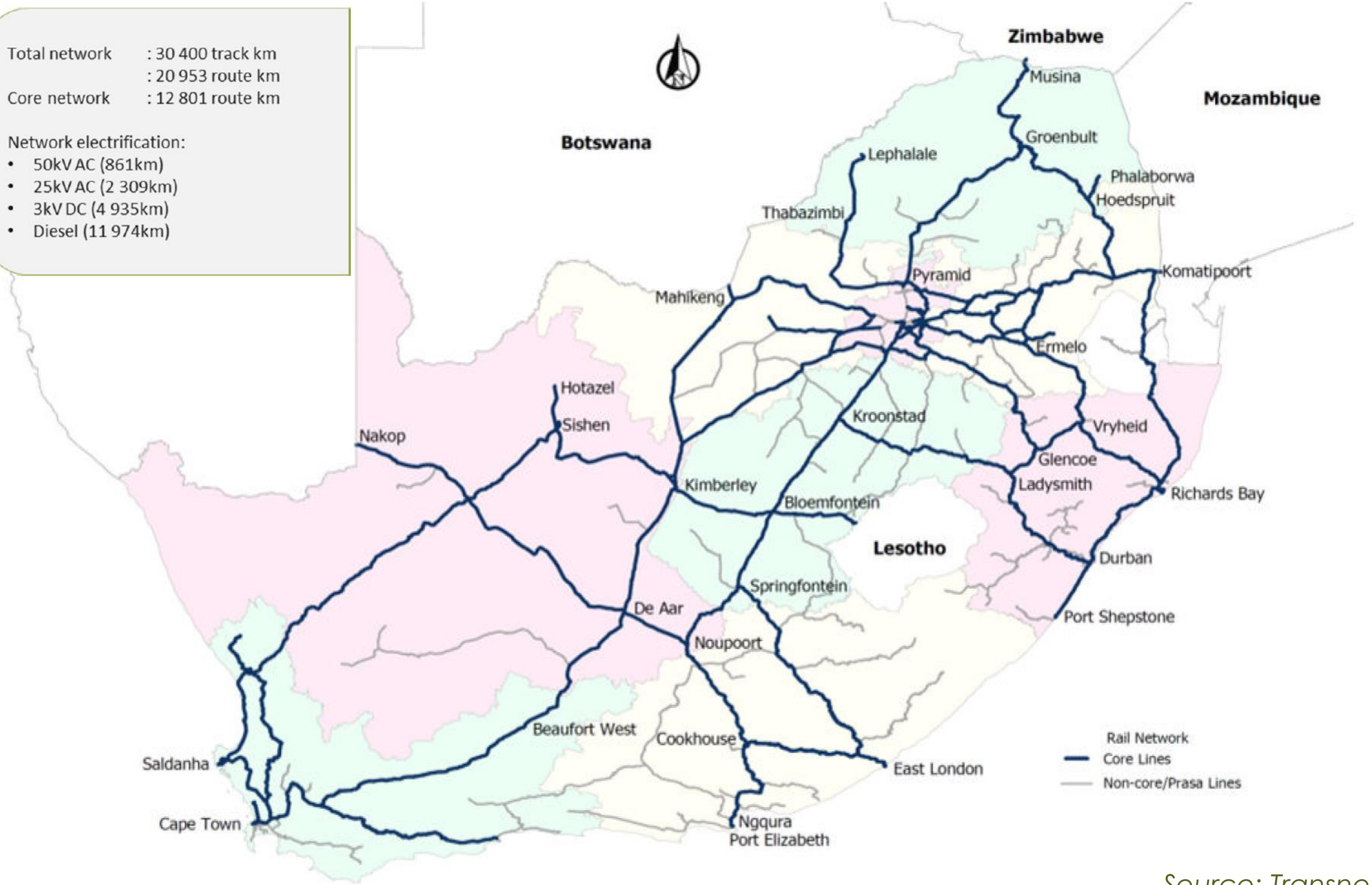
Rail in South Africa

- **SA rail network: 21,000 km**
  - *Most extensive in Africa*
  - *Ranks 13th globally in railway network*
- **SA rail traction systems:**
  - *Diesel and overhead grid-supplied electrification*
  - *Grid-supplied electricity in SA → coal*
  - *Cable theft and load-shedding: many lines can no longer support electrified traction (revert to Diesel)*
- **Alternative energy for rail would allow trains to run on any line in SA and reduce environmental impact**
- Improved service delivery from reliable non-grid-based energy will contribute to modal shift to rail, stimulate economic growth and have social benefits

SA Rail Network Electrification (Current)

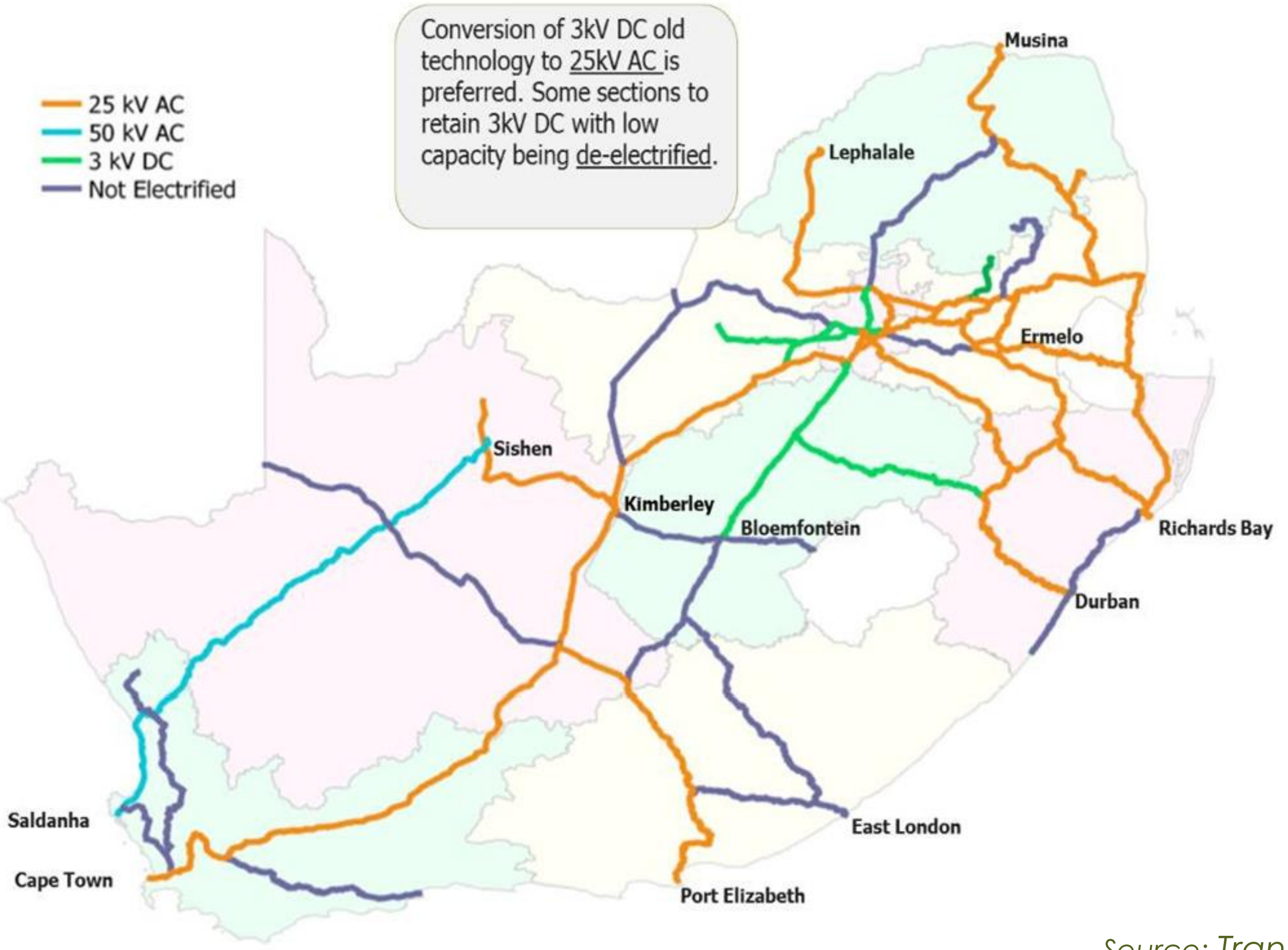
Total network : 30 400 track km
: 20 953 route km
Core network : 12 801 route km

Network electrification:
- 50kV AC (861km)
- 25kV AC (2 309km)
- 3kV DC (4 935km)
- Diesel (11 974km)



Source: Transnet

SA Rail Network Electrification (Future)



Source: *Transnet*

International trends

- **Global rail manufacturers:** sustainable, context-specific rail vehicles & varied traction options
- **Electrical traction motors:** regardless of power source
- **Electricity regeneration** during braking –recharges batteries / feed back to grid

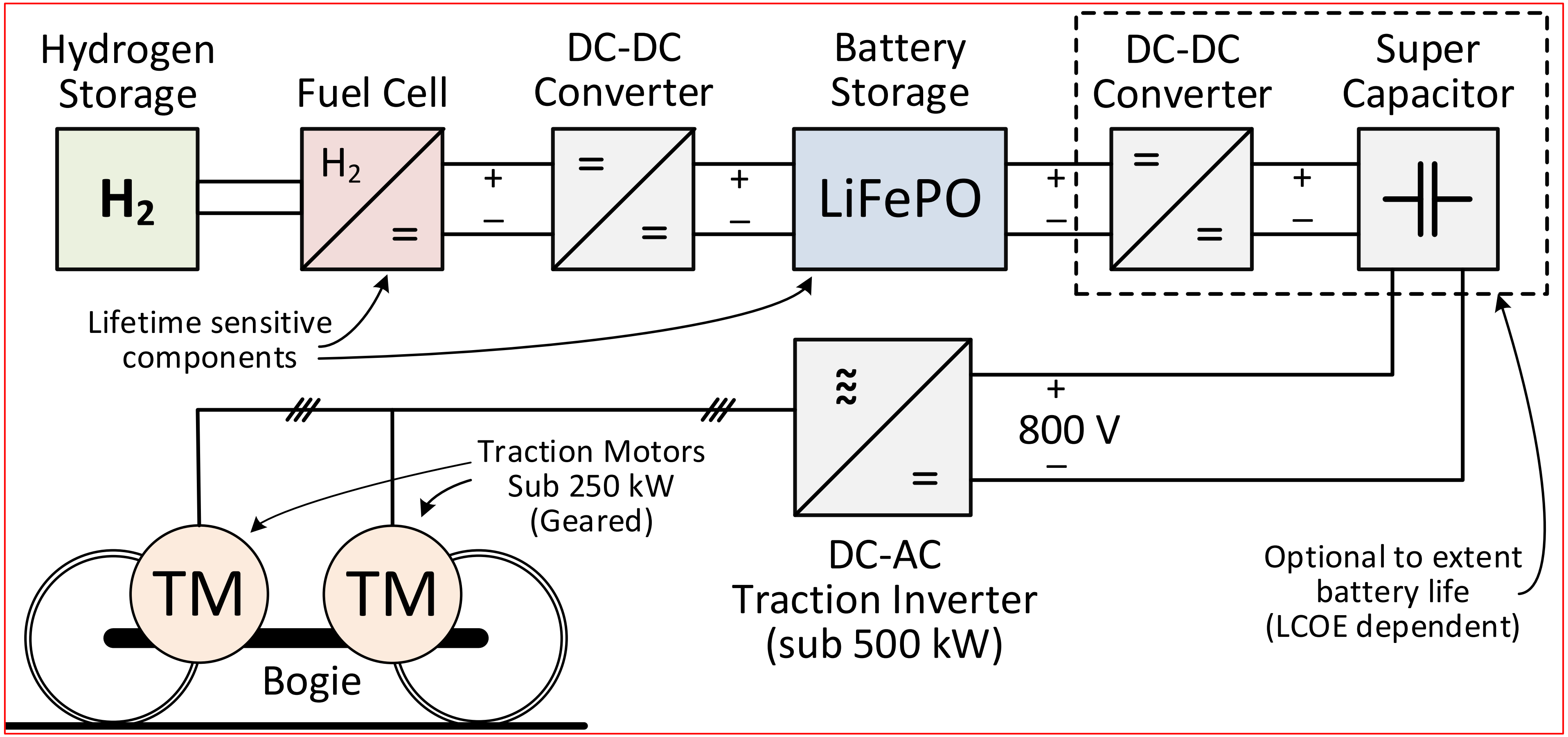
- **Primary power sources:**
  1. *Electrical: external power from overhead or 3rd rail*
  2. *Diesel ICE – renewable diesel popular in Europe, US, etc.*
  3. *Hydrogen (H_2): fuel cell / ICE (purity considerations)*
  4. *Battery: onboard batteries.*

- **Optimise rail power solutions according to operational context – may be a combination of power solutions:**
  1. *Electrical and Battery/Diesel*
  2. *Battery and Diesel/Electrical/ H_2 Fuel Cell/ H_2 ICE*

Hydrogen propulsion of trains

- **International rolling stock manufacturers using H_2 technology in freight and passenger rail**
- **Types of trains:**
  1. *Locomotive-wagon combination: Self-powered locomotive haul wagons*
  2. *Multiple units: Tractive effort distributed throughout train*
- **South Africa:**
  - H_2 energy gaining interest in various sectors, including rail (but lagging international)
  - **Required technologies:** H_2 storage tanks, H_2 fuel cells, DC-DC converters, battery storage and DC-AC inverters
  - **Retrofit:** Existing diesel engines modified to run on H_2 – cost-effective solution to transition diesel locomotives to H_2 power?

Hybrid Power System for Trains



APPROACH

4. Feasibility Study Approach

Feasibility study
If Feasible, continue to Planning (Business, Operational, Implementation)

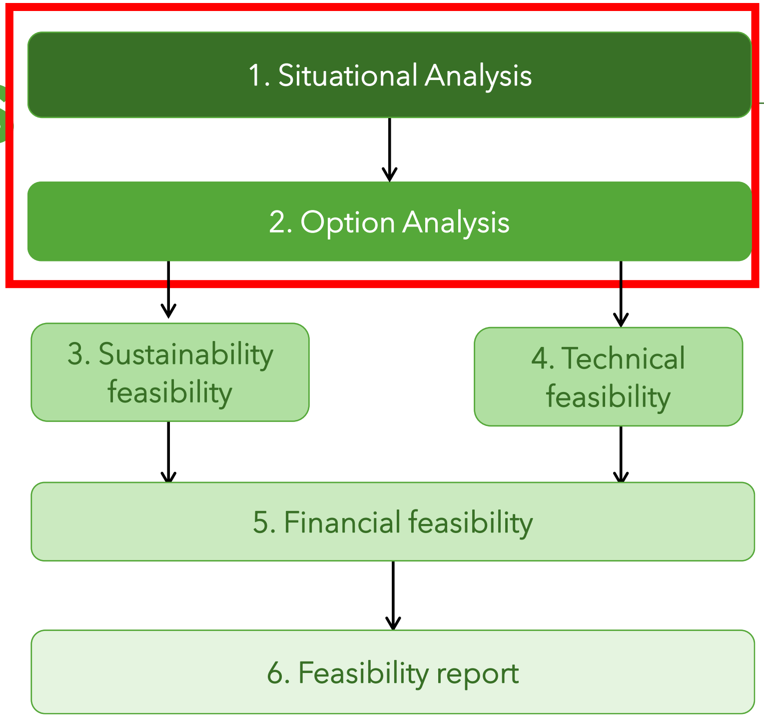
Operational, Implementation and business planning
If Funding can be secured, proceed to Pilot

Pilot (full scale train, operate on short section of route)
If Pilot successful, proceed to Full Roll-Out

Full Roll-out
If Roll-out is successful, Replicate in other areas

1. Situational Analysis
2. Option Analysis
3. Sustainability feasibility
4. Technical feasibility
5. Financial feasibility
6. Feasibility report

Situational and Option Analysis



- **Review rail situation in South Africa:**
  - *Policy and strategy alignment for rail operations*
  - *Key stakeholders, PPPs*
  - *Current rail infrastructure condition, traction and operations*

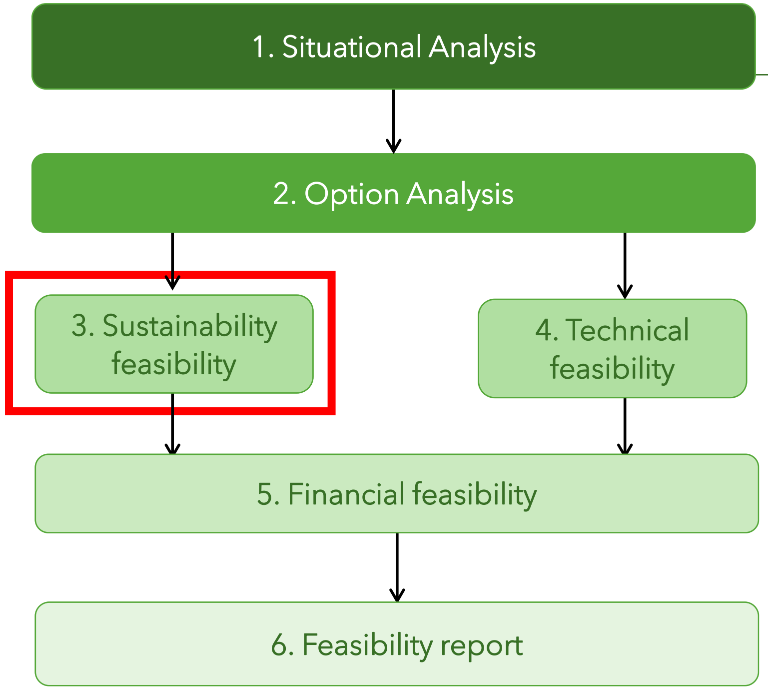
- **Identify representative rail links (freight and passenger):**
  - *Routes, Electrification, Distance from electric distribution*

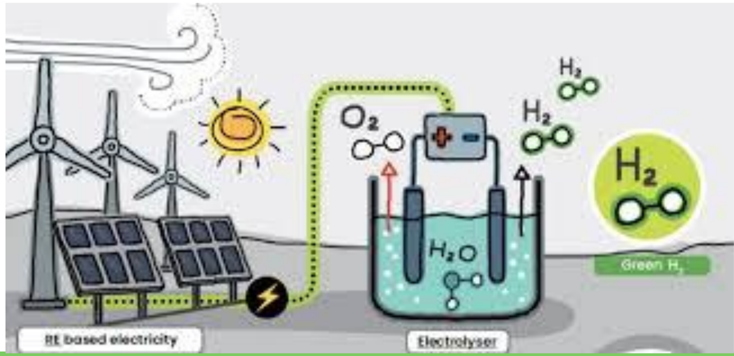
- **Evaluate each traction option for rail links, based on:**
  1. *Environmental impact*
  2. *Ease of implementation/conversion*
  3. *Range provided by each energy source (in kilometres per unit fuel)*
  4. *Stakeholder interest and support.*

Sustainability Feasibility

- **Carbon Emissions Assessment for different traction options**
  - *Environmental impact over the entire value chain.*

- **Power efficiency evaluation (input VS energy available at wheels):**
  - *Entire value chain from energy generation to train movement*
  - *Energy conversion efficiency*
  - *Energy utilisation for traction and auxiliary services*
  - *Energy losses and power factors*
  - *External factors (topography, climate and rail line length)*
  - *Operational requirements (operative profile, acceleration, speed, capacity demands and standing time).*

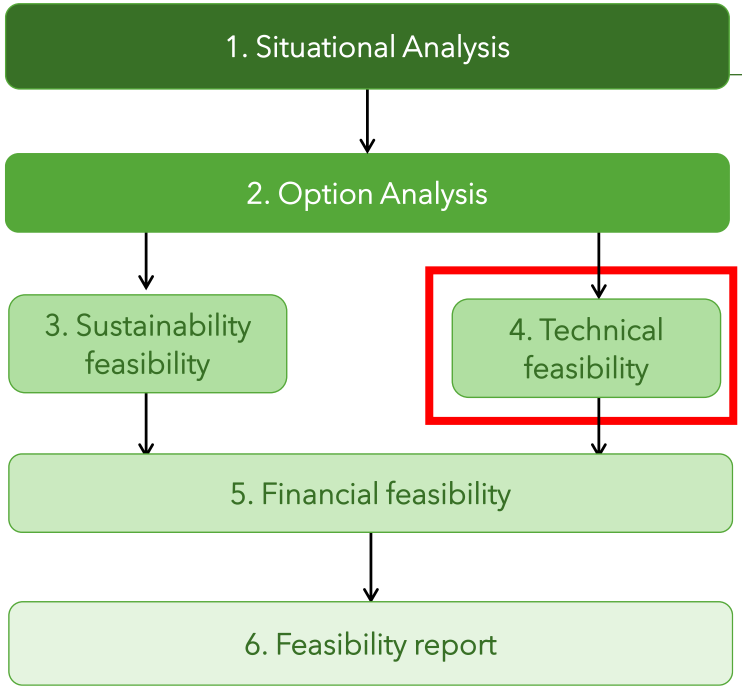




Technical Feasibility

- **Readiness of technologies in South Africa:**
  - *Hydrogen: H_2 Production Technology, Service inputs/supply, Technology Adoption*
  - *On-board batteries:*
    - *Train with hybrid (battery and electrical) propulsion system*
    - *Battery and Charging Technology*
  - *Diesel and overhead electrification*
    - *Operational aspects, Safety considerations, Current challenges*

- **Statutory, regulatory and risk considerations:**
  - *Identification of safety requirements*
  - *Circular economy*
  - *Legislative requirements (particularly for H_2 handling and batteries)*

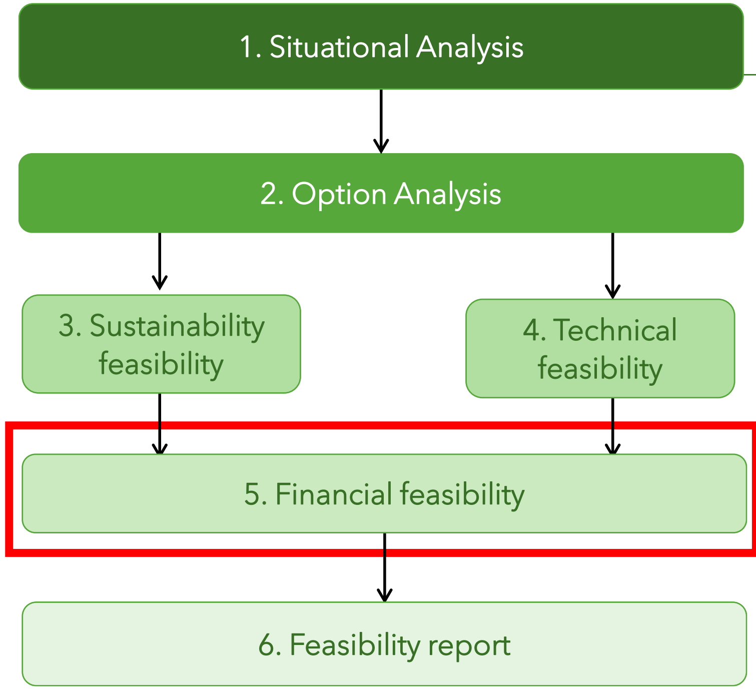


Financial Feasibility

- Input from **situational and option analyses**, **sustainability feasibility**, and **technical feasibility** studies

- Projected future income statements, balance sheets and cash flow statements
- Investment and working capital requirements
- Predicted cost structure, including operational and infrastructure subsidy and grants budgets will be determines

- Financial assessment (Financial ratios, Interpretation of findings)



Benefits

- **Benefits of project:**
  - *Operational viability of green energy source for trains tested for Africa*
  - *Evaluation of Public-Private Partnerships (PPPs) to support PRASA and Transnet*
  - *Enabling electric trains to operate on non-electrified lines*
  - *Dual-powered trains*
  - *Integration of key urban growth areas, industrial and mining activities*

- **Investor benefits**
  - ***Short term:*** *investors supporting institutional knowledge development in operations of alternative energy train systems in Africa.*
  - ***Long term:*** *involvement in developing and testing sustainable rail tractive technology for South African context.*
  - ***Co-branding, public participation, and joint research***

THANK YOU

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