Electric vehicles and load shedding
MJ (Thinus) Booysen

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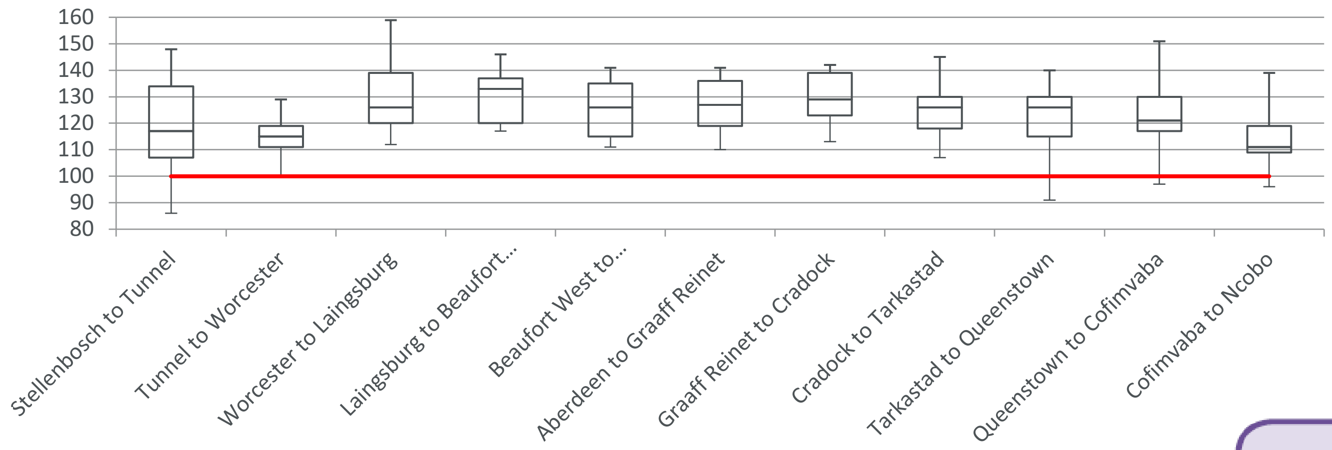
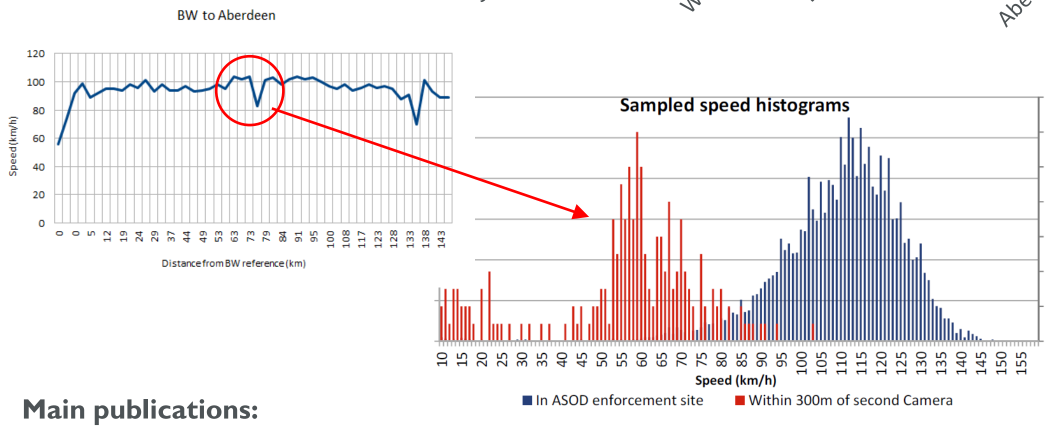
Photo by Stefan Els

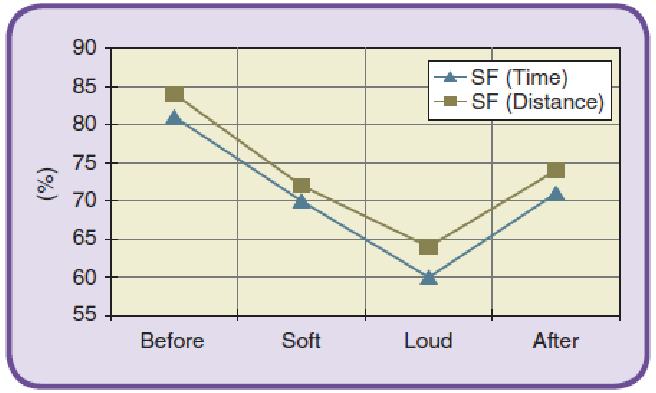
Engineering | EyobuNjineli | Ingenieurswese

Safety

- Responsible for more than 70% of travel in sub-Saharan Africa







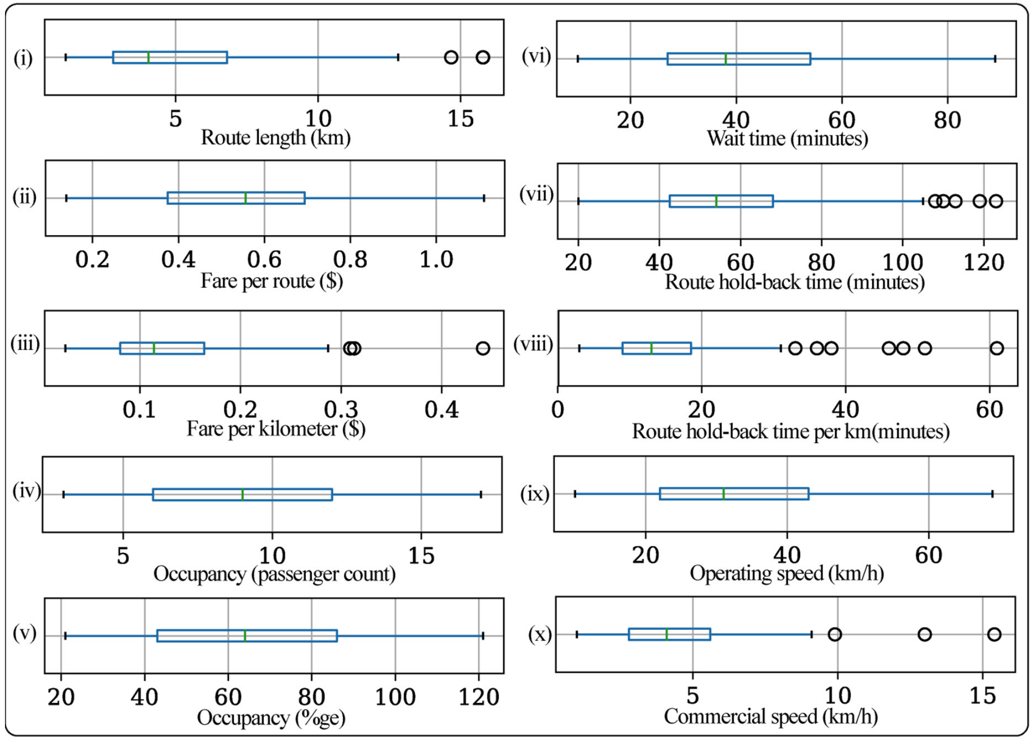
Main publications:

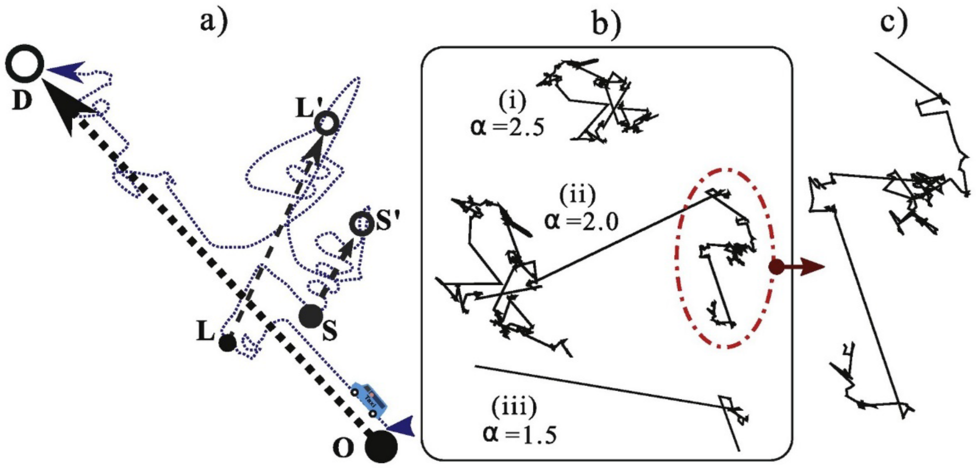
Booysen, M. J., Andersen, S. J., & Zeeman, A. S. (2013, October). Informal public transport in Sub-Saharan Africa as a vessel for novel Intelligent Transport Systems. In 16th International IEEE Conference on Intelligent Transportation Systems (ITSC 2013) (pp. 767-772). IEEE. https://ieeexplore.ieee.org/document/6728324/ 39

Akpa, N. E. E., Booysen, M. J., & Sinclair, M. (2016). Auditory intelligent speed adaptation for long-distance informal public transport in South Africa. IEEE Intelligent Transportation Systems Magazine, 8(2), 53-64. https://doi.org/10.1109/MITS.2016.2533979

Mobility patterns

b) General distribution of route attributes





Main publications:
Ndibatya, I., & Booysen, M. J. (2020). Minibus taxis in Kampala's paratransit system: Operations, economics and efficiency. Journal of Transport Geography, 88, 102853. https://doi.org/10.1016/j.jtrangeo.2020.102853. Ndibatya, I., & Booysen, M. J. (2021). Characterizing the movement patterns of minibus taxis in Kampala's paratransit system. Journal of Transport Geography, 92, 103001. https://doi.org/10.1016/j.jtrangeo.2021.103001.

Electric mobility

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Vehicles

Electric Minibis Taxi Import

Topic: Importing the 1st electric minibus in SA for assessment
Context: Single vehicle to reside on STB campus. Owned by GM.
Funders: GoMetro, STB Uni (MTN Lab & CRSES), Mix Telematics, HSW Management Services
Partners: GoMetro, STB Uni (MTN Lab & CRSES), Mix Telematics, HSW Management Services

Electric Minibis Taxi Retrofit

Topic: ICE minibus taxi retrofit to EV
Context: Uni minibus retrofitted with electric propulsion
Funder: Stellenbosch University and ???
Partners: Stellenbosch University, Oxford University, Rham, Wits*, ??

Electric Vehicle Energy Assessments

Topic: Assess vehicle energy requirements
Funders: MTN Lab, Stellenbosch Uni (E&E)
Partners: Oxford Uni, Stellenbosch Uni

Golden Arrow Bus Service*

MellowVans*

World Bank Project

Topic: Impact of decarbonising minibus taxis.
Context: Gauteng and Western Cape associations
Funder: World Bank
Partners: Stellenbosch Uni, Oxford University, Nodalis, Transitec, Montfort Projects
Duration: 1 year

Infrastructure

LEAP-RE Project

Topic: Battery-powered charging stations for EVs in Africa
Funders: Department of Science and Innovation, EU
Partners: TUM, Stellenbosch Uni, Adama Science & Tech Uni, French Alternative Energies & Atomic Energy Comission
Duration: 3 years

Stellenbosch Municipality Charging Stations

Topic: Charging stations at Stellenbosch main taxi rank (6 parking bays)
Funders: uYilo, ACDC*, D4TA*
Partners: GoMetro, Stellenbosch Munic, Stellenbosch Uni
Duration: end 2023

Charging Stations on Campus

Topic: Arrange for the installation of three additional charging stations on Stellenbosch campus
Funder: Stellenbosch Uni and GOMetro
Partners: Stellenbosch Uni (Facilities management, E&E Engineering), GoMetro

Schools and taxi ranks with solar power *

Topic: Use schools and taxi ranks to provide solar power for charging and communal electricity
Funder: TBD (EnCat9 and/or RISA UK)
Partners: Stellenbosch Uni, Oxford Uni, Drakenstein Muni, Western Cape Education Dept.

Operations

Simulation Model Improvement

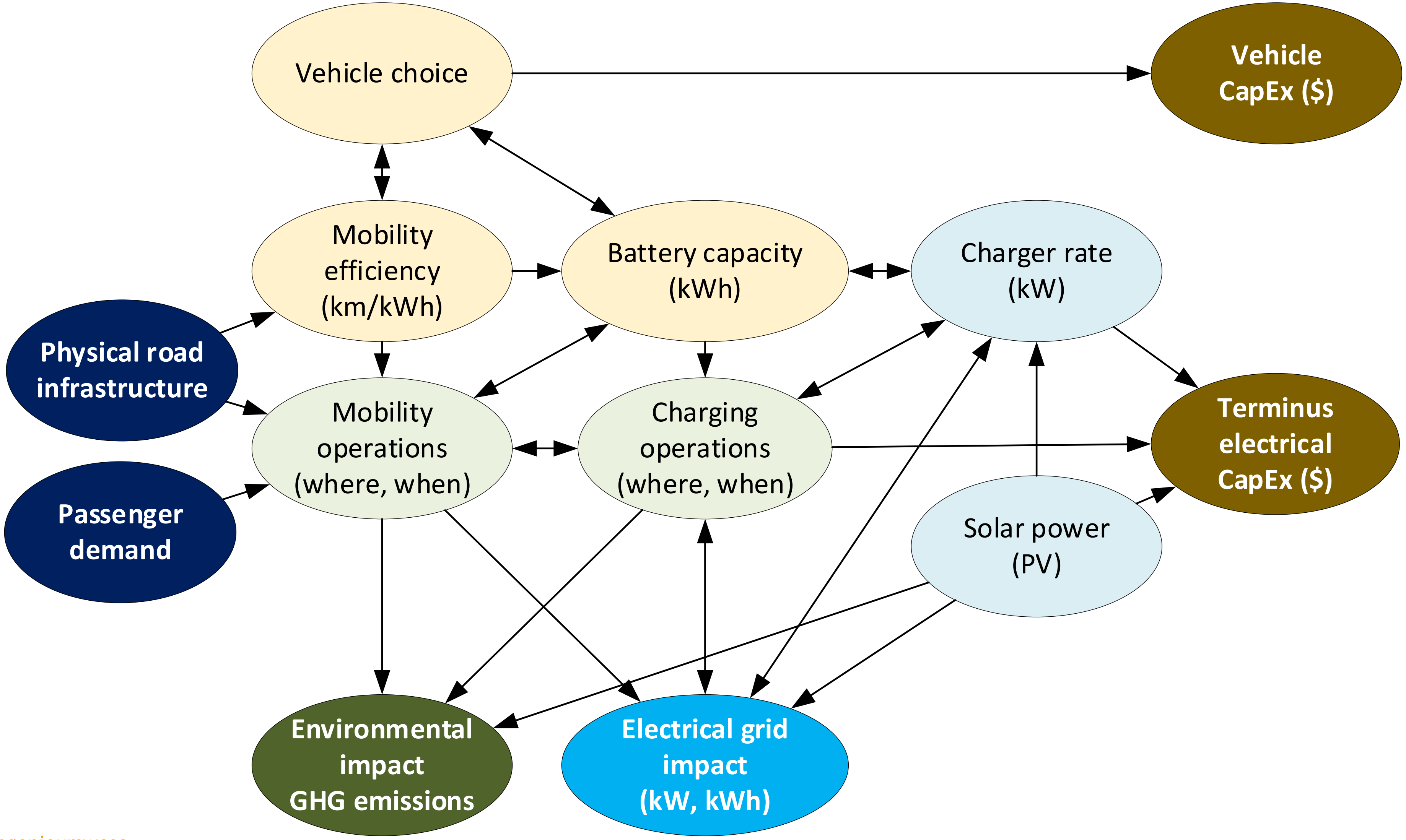
Topic: Improve the excisting SUMO model to match SSA conditions and include charging station requirements
Partners: Stellenbosch Uni, Oxford Uni

eMBT Scheduling

Topic: Optimal scheduling of eMBT operations plans to match EV ranges and charging requirements
Partners: Stellenbosch Uni, TESS

*TBC

Aspects to consider in electric mobility



Charge rate matters

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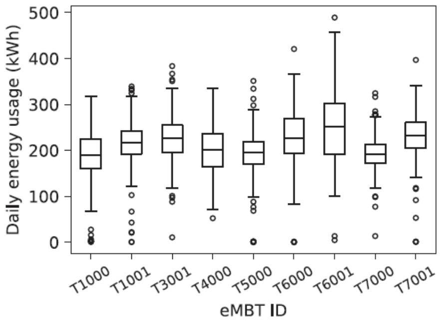
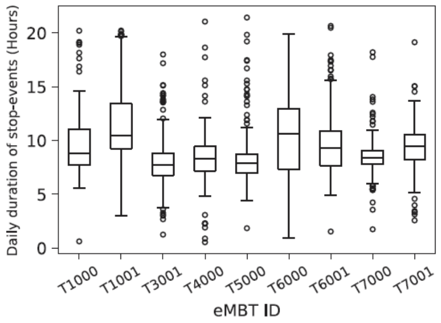
- Chargers range from 2kW to 150kW
- Even with very slow charging 4 million vehicles brakes an “operational” grid
- With fast charging 50 thousand vehicles brakes an “operational” grid
- Currently grid has a shortfall of 7,000 fast (2 mil slow) chargers
- Perspective is important
  - Impact on the grid,
  - the user, and
  - the charging service provider

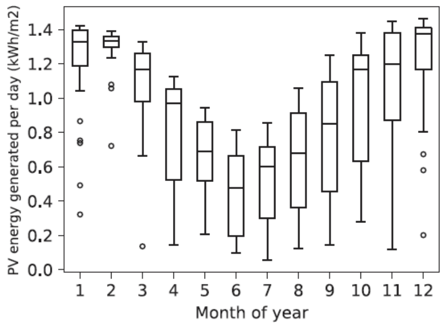
Paratransit – electrification, the vehicle



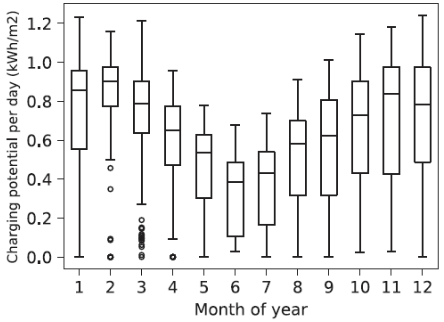
(a) Energy used per eMBT.



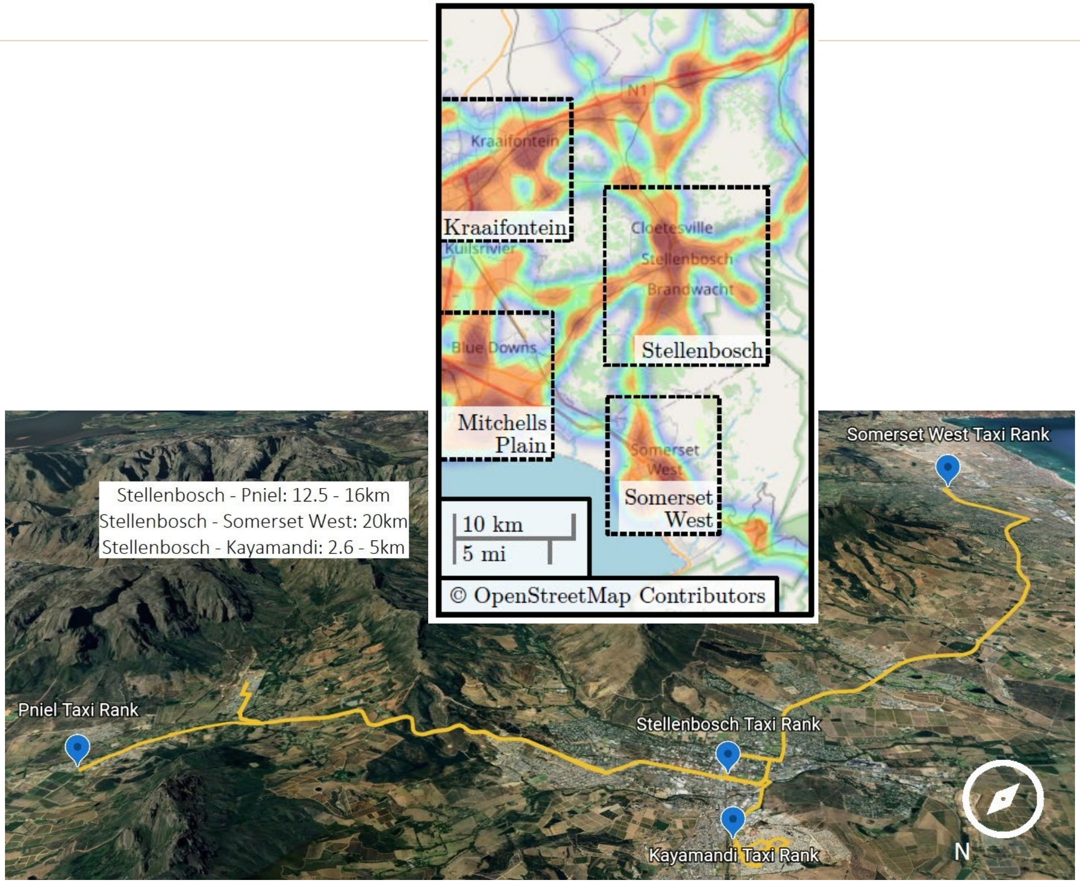
(b) Durations of stop events per eMBT.



(c) PV generation per m^2 per month.



(d) PV charging potential per eMBT per m^2 per month.



Main publications:

Buresh, K. M., Apperley, M. D., & Booysen, M. J. (2020). Three shades of green: Perspectives on at-work charging of electric vehicles using photovoltaic carports. Energy for Sustainable Development, 57, 132-140. https://doi.org/10.1016/j.esd.2020.05.007.

C.J. Abraham, A.J.Rix, I. Indibatya, M.J. Booysen "Ray of hope for sub-Saharan Africa's paratransit: solar charging of urban electric minibus taxis in South Africa", Energy for Sustainable Development, 2021. https://doi.org/10.1016/j.esd.2021.08.003.

Booysen, M. J., Abraham, C. J., Rix, A. J., & Ndibatya, I. (2022). Walking on sunshine: Pairing electric vehicles with solar energy for sustainable informal public transport in Uganda. Energy Research & Social Science, 85, 102403. https://doi.org/10.1016/j.erss.2021.102403.

Simulation and virtualization

Mobility data

- Different perspectives
  - Route-centric – transport/civil engineering planner
  - Driver-centric – operations planning
  - Vehicle-centric – required for electrification planning
- Different methods of data capture/store
  - GPS traces
    - Minutely (1/min) vs. secondly (1Hz)
    - Tracker or OBD2 port
  - Origin/destination data
  - Standardised passengers
- Different information
  - timestamp, geolocation, speed, heading, driver information, vehicle informatio

Simulation and virtualization

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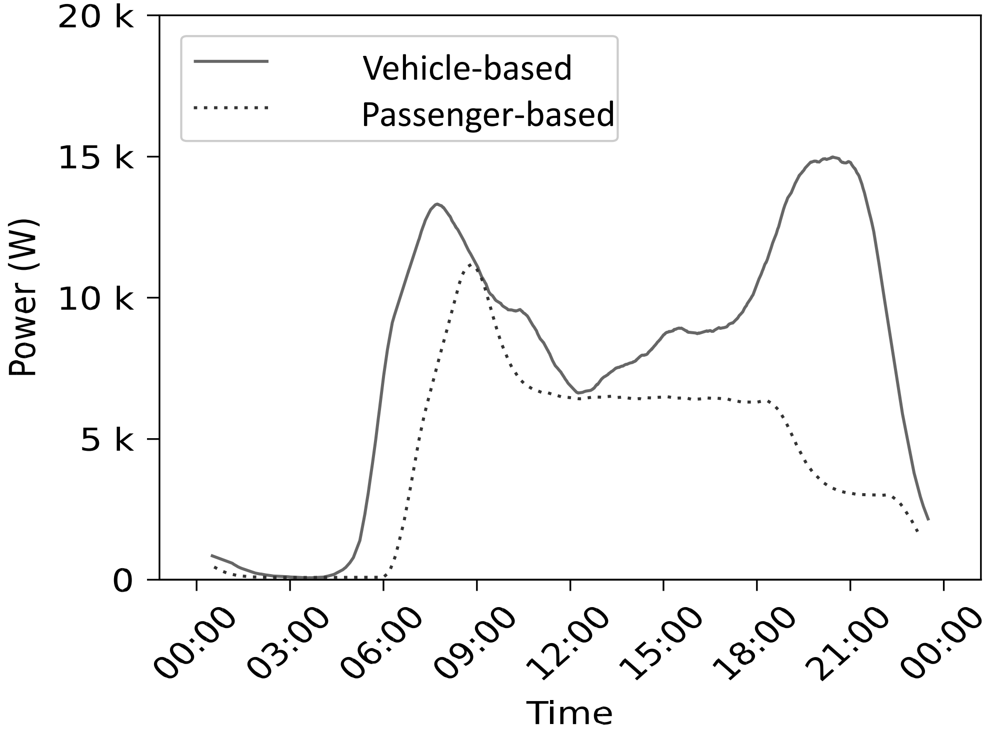
Mobility data

- Standardised passenger vs. vehicle tracking



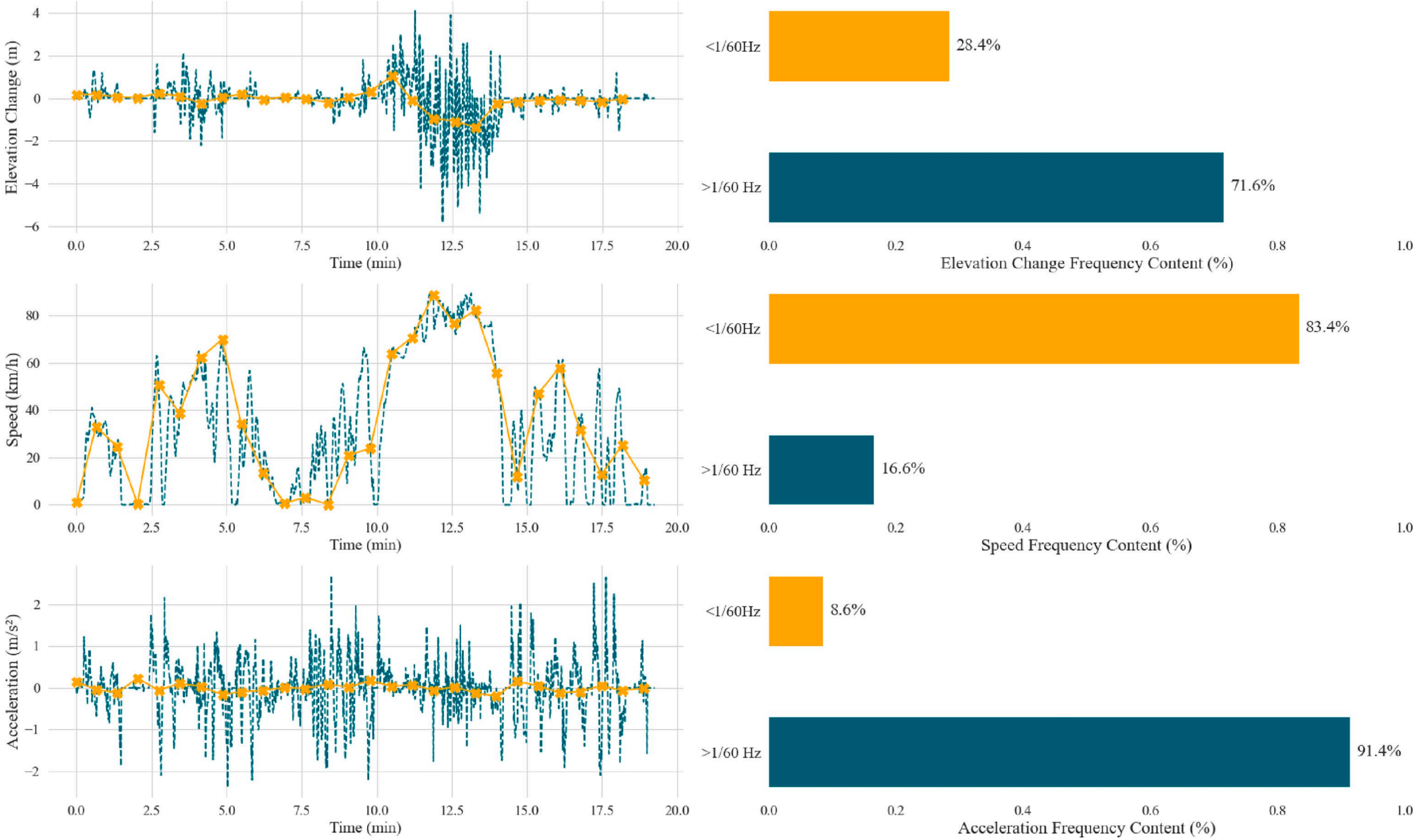
Main publications:

A.J. Rix, C.J. Abraham, M.J. Booysen, "Why taxi tracking trumps tracking passengers with apps in planning for the electrification of Africa's paratransit", iScience, 2022. https://doi.org/10.1016/j.isci.2022.104943

Simulation and virtualization

Mobility data

- 1Hz vs 1 min data



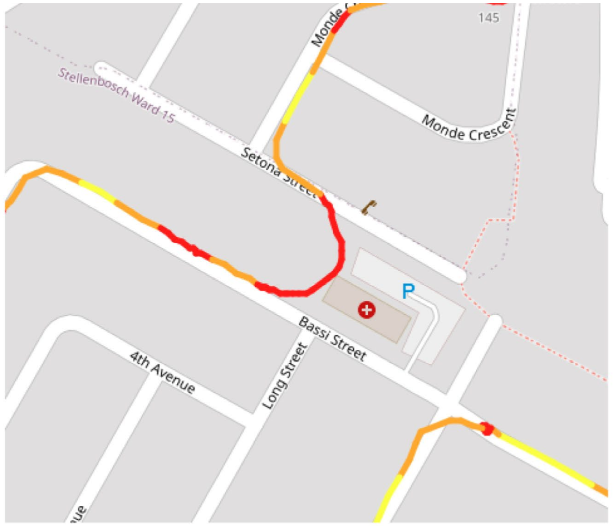
Main publications:

C.R. Hull, J.H. Giliomee, K.A. Collett, M. McCulloch, M.J. Booysen, "Using high resolution GPS data to plan the electrification of paratransit: a case study in South Africa", Transportation Research Part D, 2023.
https://doi.org/10.1016/j.trd.2023.103695

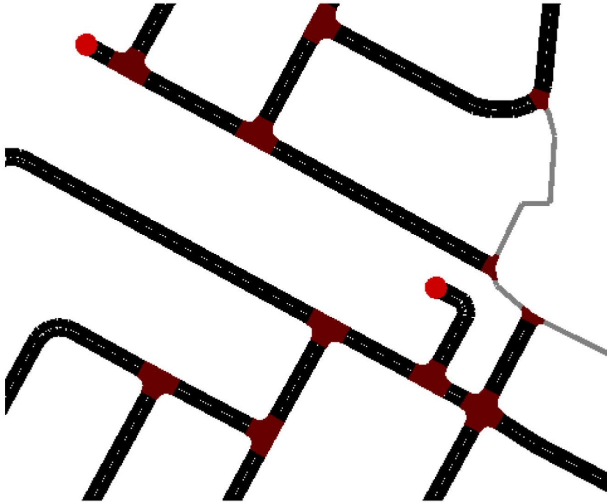
Simulation and virtualization

Virtual maps

- Maps mispatch to roads
- Drivers don’t stick to roads



(a) Actual route taken from Bassi to Setona Street



(b) Road network file of Bassi and Setona Street

(c) As seen from Bassi Road

(d) As seen from Setona Street

Main publications:

J.H. Giliomee, C.R. Hull, K.A. Collett, M. McCulloch, M.J. Booysen, “Simulating Mobility to Plan for Electric Minibus Taxis in Sub-Saharan Africa’s Paratransit”. https://doi.org/10.1016/j.trd.2023.103728

Simulation and virtualization

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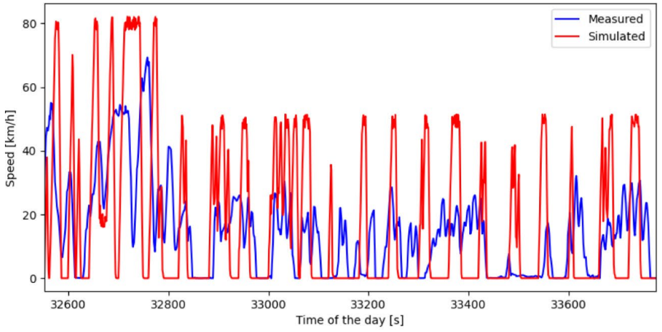
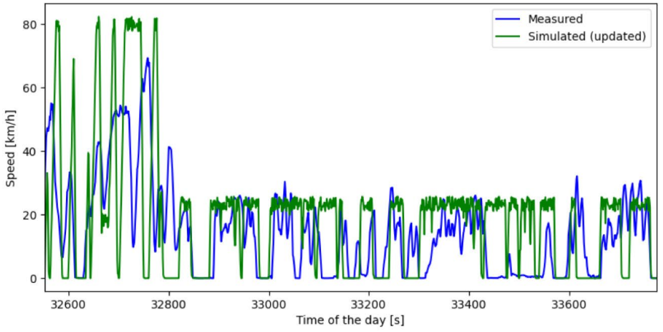
Virtual drivers

- Acceleration (departures, breaking)
- Speed
- Stop adherence



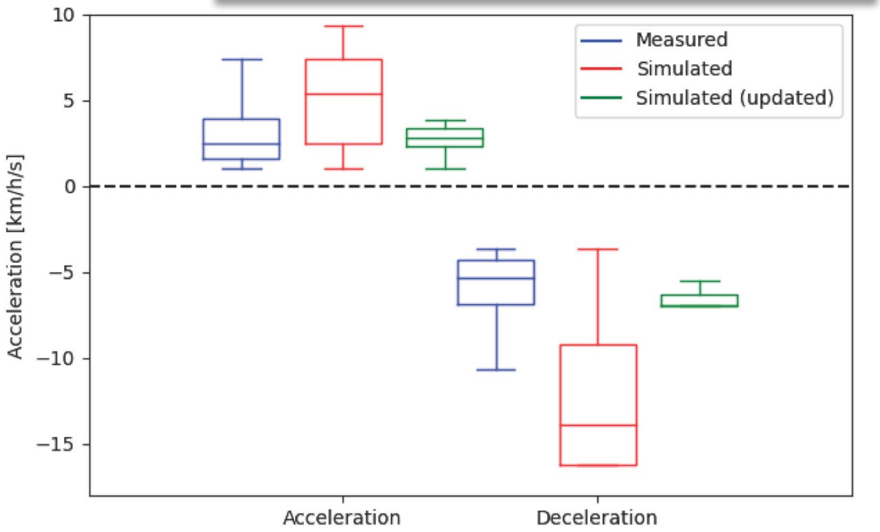
(a) Urban Route 1 before improvement



(b) Urban Route 1 after improvement

Route	Stop signs encountered	Vehicle stoppeda, b	Stop sign ratio (%)
Urban 1	64	17	26.6
Urban 2	12	4	33.3
Inter-city 1	36	13	36.1
Inter-city 2	21	6	28.6
Uphill	63	19	30.2
Downhill	49	13	26.5
Total	245	72	29.4

Aspect	Consumption if uncorrected [kWh/ km] (% error)
Driver acceleration	0.64 (+21 %)
Elevation	0.54 (+2 %)
Legal speed limits	0.52 (−2 %)
Residential driver speed profile	0.52 (−2 %)



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J.H. Giliomee, C.R. Hull, K.A. Collett, M. McCulloch, M.J. Booysen, "Simulating Mobility to Plan for Electric Minibus Taxis in Sub-Saharan Africa's Paratransit". https://doi.org/10.1016/j.trd.2023.103728

Simulation and virtualization

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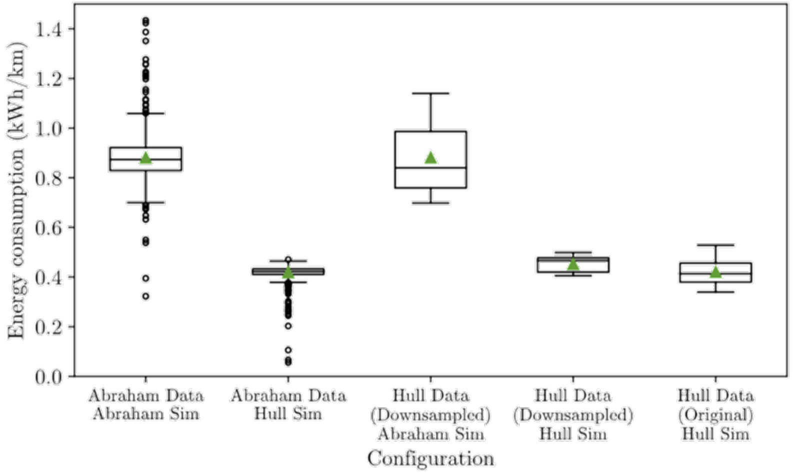
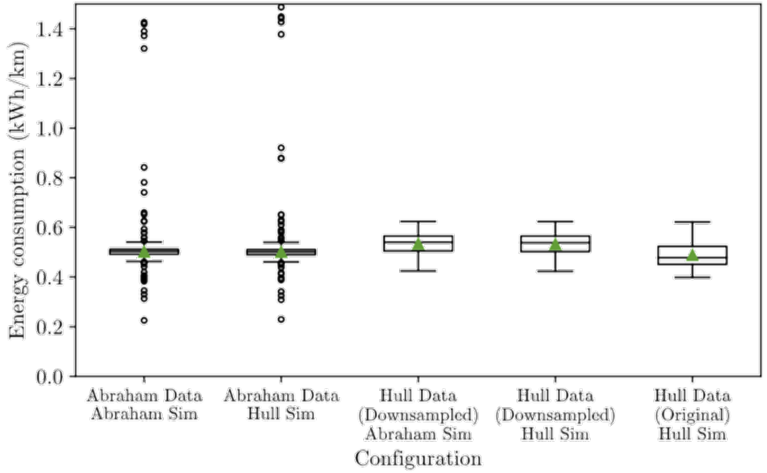
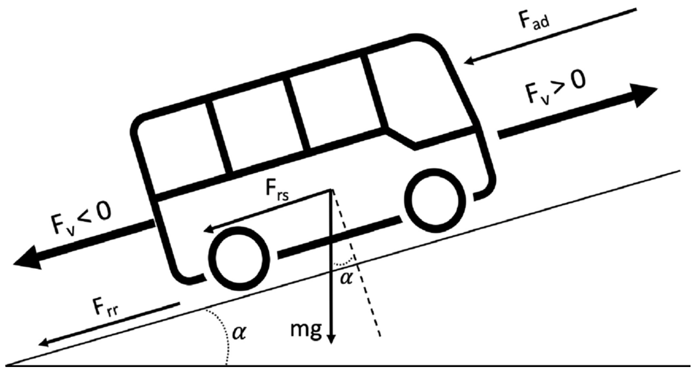
Electro-kinetic model

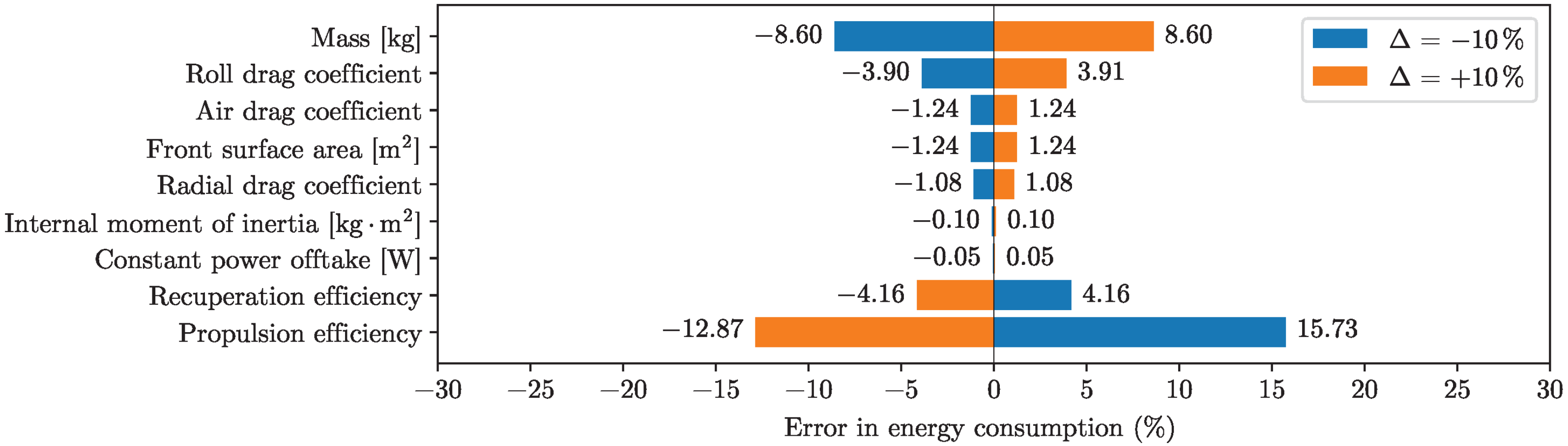
Original models



Aligned models







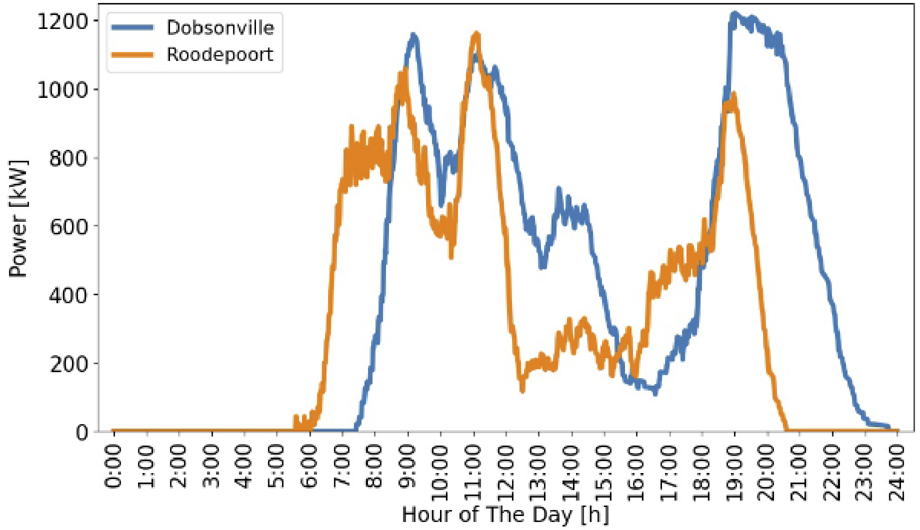
Main publications:

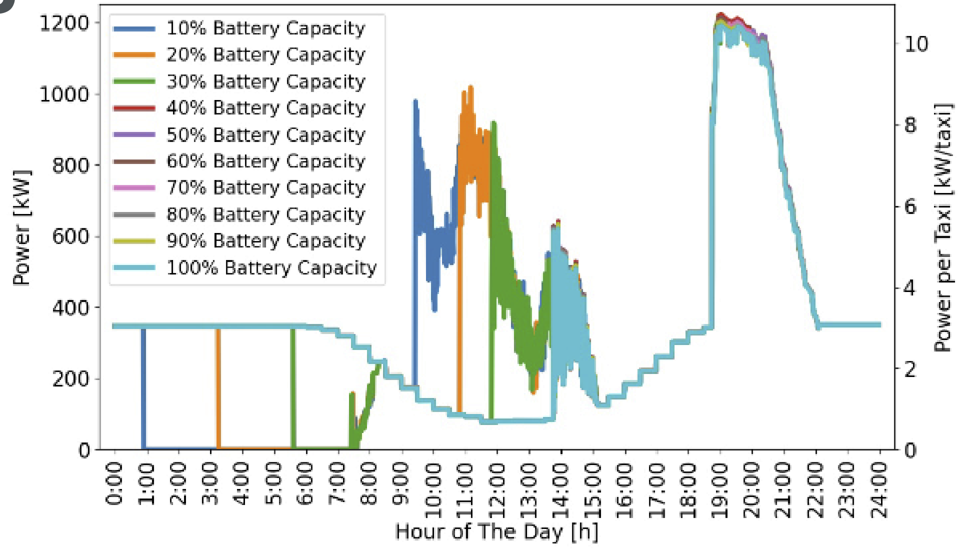
C.J. Abraham, A.J. Rix, M.J. Booysen, "Aligned simulation models for simulating Africa's electric minibus taxis", *under review*.

Grid impact and offsetting

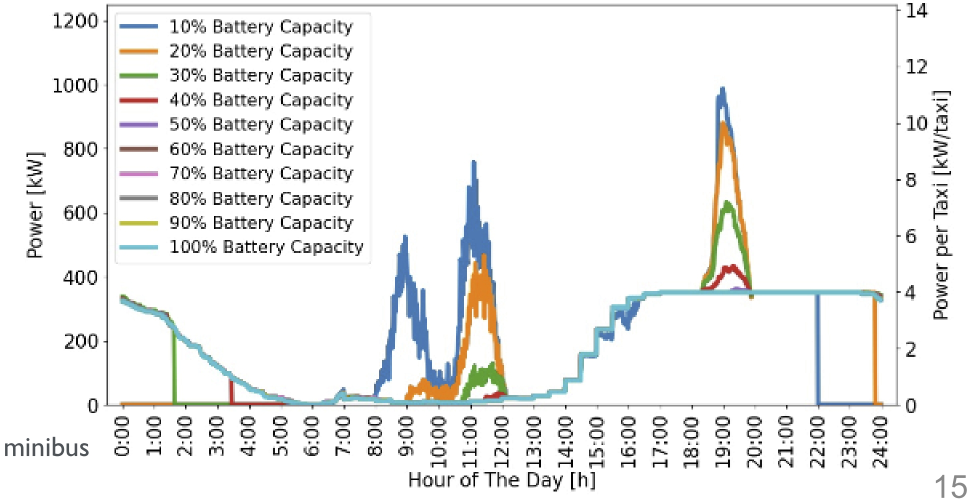
Use of solar power and battery storage

- Power peaks overlap with problematic grid peaks
- Grid impact reduced
- Using stationary battery 60kWh/taxi, 9.5 kW_{pk}/taxi solar
- Peak load down 69%: 13 to 4 kW/taxi
- Energy down 47%: 87 to 47 kWh/taxi





(a) Dobsonville



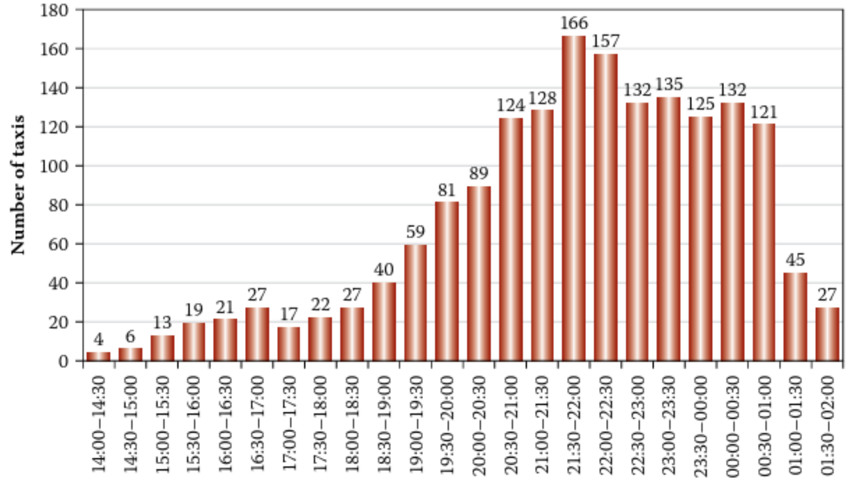
(b) Roodepoort

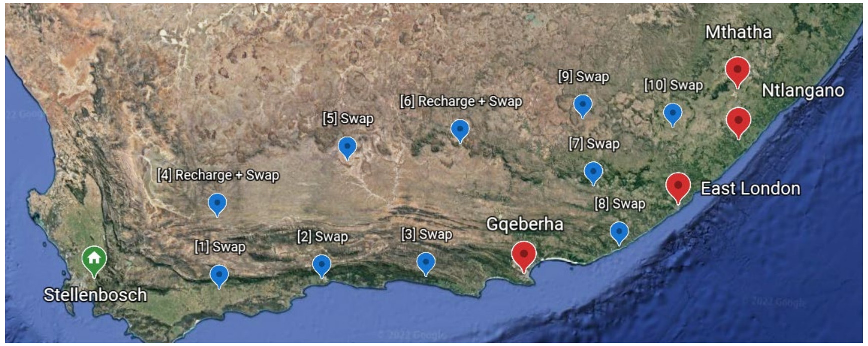
Main publications:

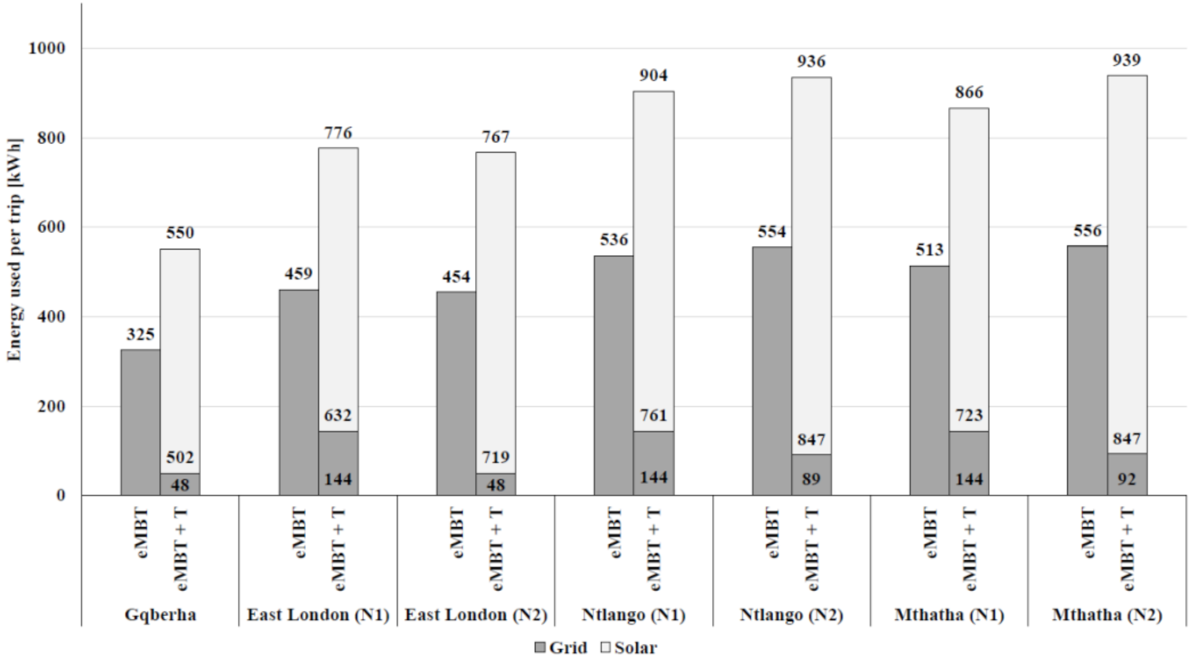
L. Fuessl, B. Thomas, M.J. Booysen, "Harnessing nature: Using solar and wind power with stationary battery storage for electric minibus taxis", IEEE Vehicle Power and Propulsion, Aug 2022,Merced, California, USA. https://doi.org/10.1109/VPPC55846.2022.10003300

Long-Distance

Use of solar power and battery storage







Main publications:

J.H. Giliomee, M.J. Booysen, "Decarbonising Africa's long-distance paratransit: Battery swapping with solar-charged minibus trailers", Transportation Research Part D, 2023. https://doi.org/10.1016/j.trd.2023.103647

Importing electric minibus taxis

Importing a HIGER Electric minibus with
MiX Telematics, GoMetro, HSW, ACDC

Retrofit of minibus taxis

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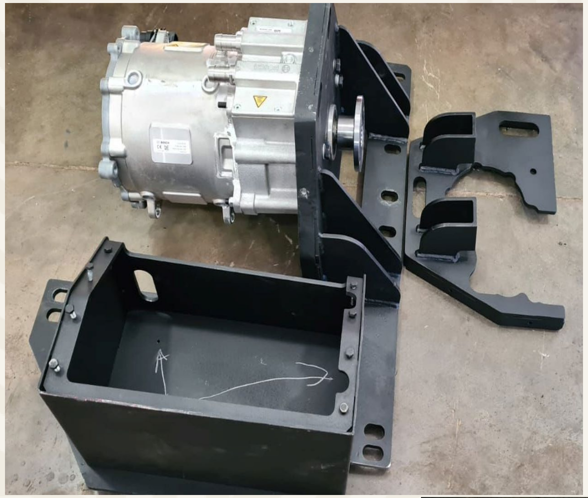

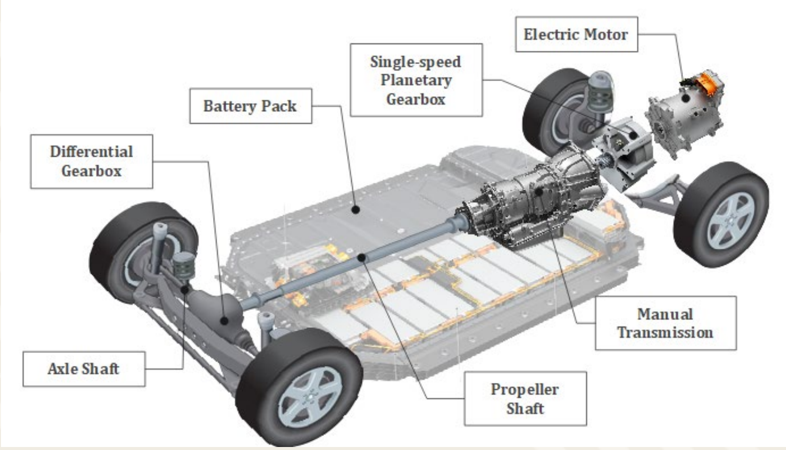

Stand alone solar charger

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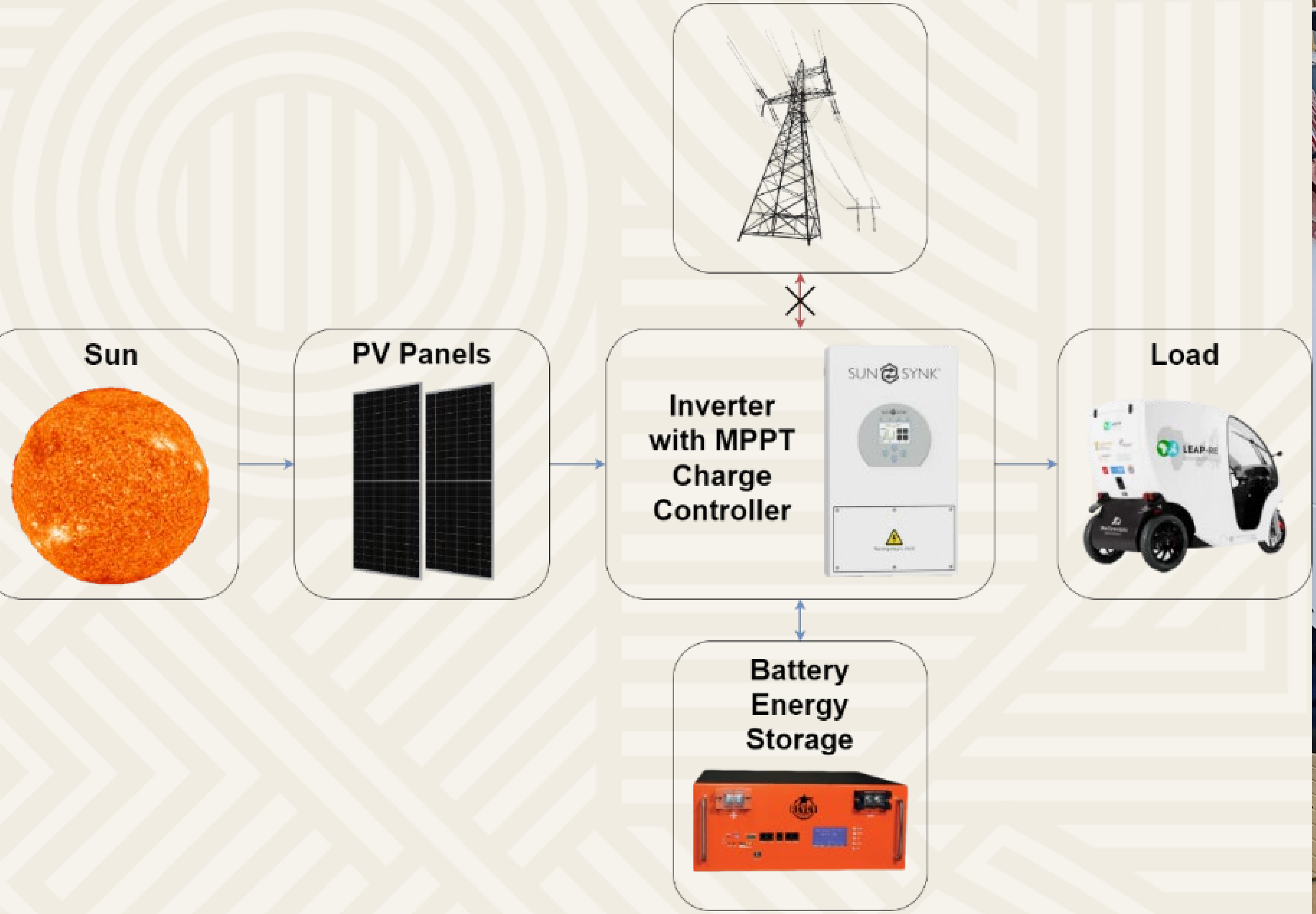
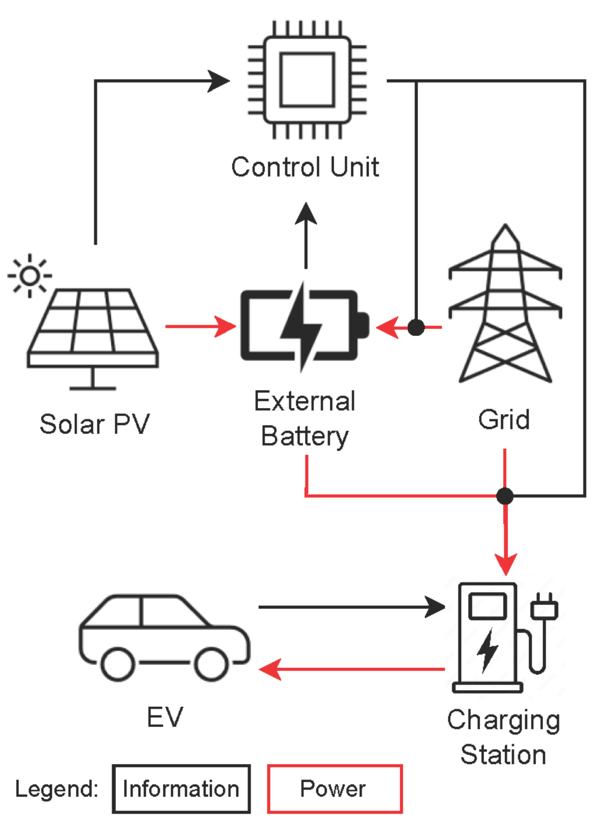


Main publications:
Home power backup systems – electrical engineers answer your questions: The Conversation

Vehicle to grid

Vehicle to grid applications

- Currently working on assessing vehicle-to-grid applications to use vehicles as mobile batteries for grid stabilisation.



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