SABOA Conference

UJ EV Bus Project

UNIVERSITY OF JOHANNESBURG

August 2024

UNIVERSITY OF JOHANNESBURG

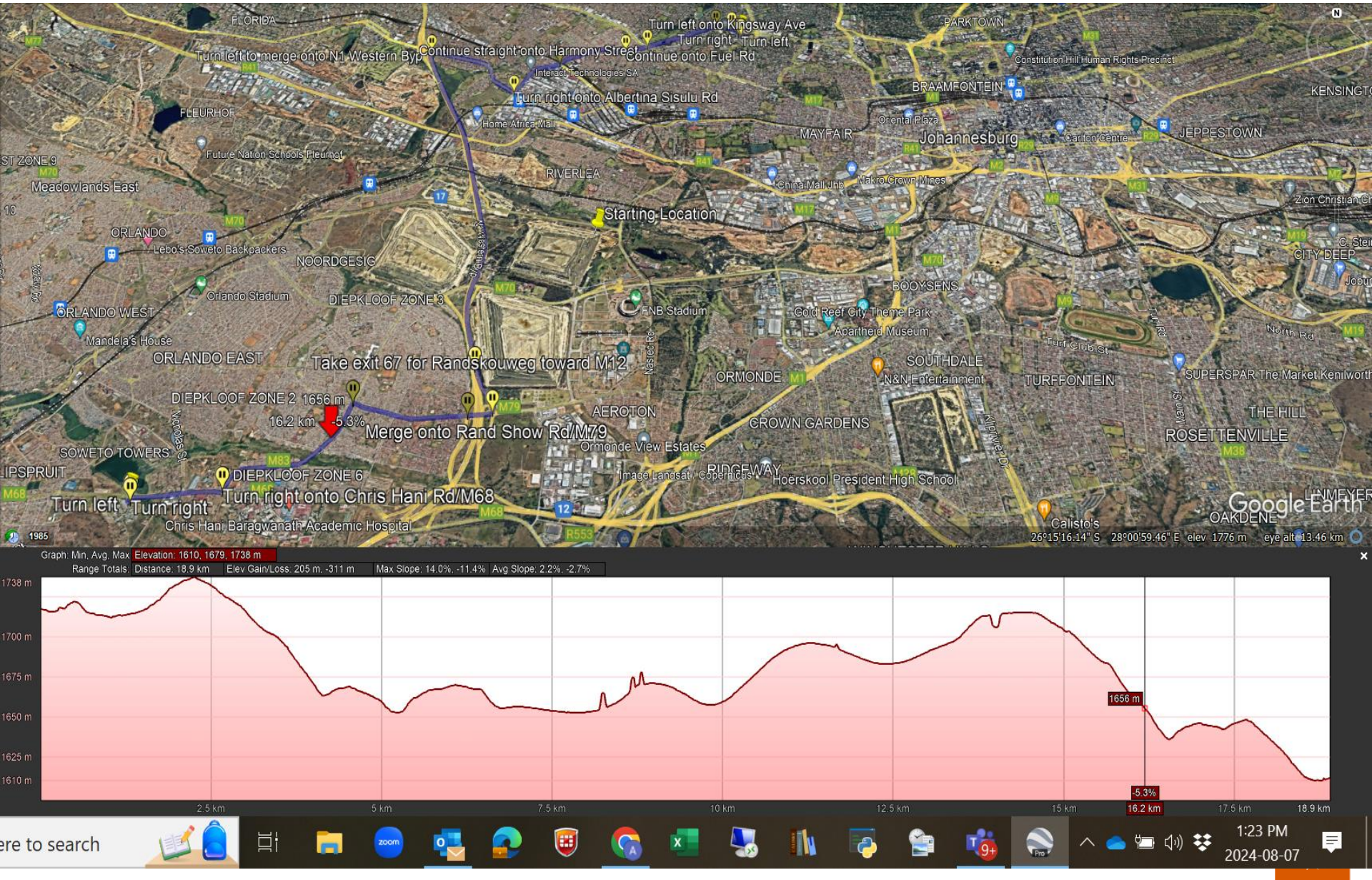
Introduction to the UJ Intercampus Bus Service

- UJ runs an intercampus bus service via an SLA with Stabus signed in 2019 – this transports around 1.5million student trips in the 10 months per year that there are academic terms.
- The service has operated since 2011 when the first intercampus bus service started (13 buses growing to 17 buses now).
- UJ also operates a short stop shuttle bus service for off-campus residences located near to the Doornfontein campus – this has been in place since November 2021.
- Routes operate from 0600 to just before 2200 evry day in the week and 0800 to 1700 on Saturdays and limited Sunday operations.

UJ route information

- As can be seen on next slide actual elevation gains / losses on the routes are limited to value of +/- 6deg.
- There are only 4 different routes catered for
  - APK – SWC – 20km
  - APK – APB – 1.6km
  - APB – DFC – 7.5km
  - DFC – SWC – 21km
- There are no intermediate stops on route – part of the licensing agreement.
- Practically the bus service tends to move students from other campuses to the main APK campus in the morning and in the reverse directions in the afternoons / evenings.

UJ APK – SWC route



Background

- Since 2017 there was at UJ Facilities Management and Logistics an earnest discussion about UJ sustainability and survivability.
- Survivability implied reducing exposure to high risk (financial) events.
- Sustainability implied reducing exposure to uncontrolled utility costs, reducing carbon footprint and delivery risk.
- Solar PV was selected as a way of addressing both and immediately a test installation of 300kWp solar photovoltaic was installed.
- Facilities Management and Logistics started considering alternatives for the Intercampus Bus Service in 2019 with reviews of
    - LPG gas assisted IC
    - Hybrid electric
    - Battery electric
    - Hydrogen Fuel Cell

Background 2

- Considered
    - Supplier and local support for each,
    - Range and overheads,
    - Future for a 10-15 year span (beyond that new techs would appear), and
    - Capex and Opex costs of each from public studies in EU / USA.
- Realised that UJ would not receive any subsidies for this – this was very different to universities in the USA which receive substantial funding support for replacing diesel with either electric or hydrogen fuel cell (UIUC run 15 hydrogen fuel cell buses each costing more than USD2.15m – mostly paid for via DoE subsidies of up to 85%)
- While worried about carbon footprints UJ Logistics ignored this from an RoI perspective – we assumed that UJ / SA carbon tax “costs” would remain below international levels for the foreseeable future – which is presently still the case.

Bus Specifications

UJ Logistics settled on the following basic specifications

- Buses to have design range of 320km with standard battery
- Ability to place smaller battery packs for some buses in the future if allocated to shorter circular or shuttle usage
- Battery packs to accommodate design range with 95 to 20% discharge
- Lower than 20% battery level only available for emergency use
- Recharge times to be less than 5 hours for >20% battery level
- 65-seater and 20 standing (but no special disability entry or exit)
- Battery warranty of 7 years or at least 3 000 discharges from 95 to 20%
- Battery pack space to accommodate 2 major battery pack brands
- At least a 40% local content of bus by value
- Demonstration bus with a month rental option

Economic Modelling

- Based on multi-year diesel bus data for our routes.
- Used small test data for electric bus data (from UJ rental of demonstration bus for 3 months and also tested against internet reported data as well as UIUC data for 12 electric buses in UC).
- Cost of funds based on UJ actual values.
- Routes and student numbers based on historical (non-Covid) numbers.
- Multi-year predictions were based on actual increases in diesel and electricity and SLA based charges.
- Maintenance charged from diesels vs estimates for the EV buses.
- After 12 months operations reviewed the economic model and updated future estimates and replaced estimated EV bus charges with actual data.

Economic Modelling 2

- Compared a 15-year chassis life and 7.5 through 9-year battery life
- Compared using Eskom and UJ solar PV electricity costs
- Did a sensitivity analysis of expected kWh/km ranging from 1.0 through 2.5kWh/km (actual measured was roughly 1.75kWh/km on UJ routes)
- Bus costs at R5.5m through R6.5m (inc VAT)
- Charging stations at GridCars costs
- Have proven that the 5.5 – 5.75-year payback period is being met easily at this point with 1.5 years operational data
- Actual battery degradation measurements indicate that the 3 000 discharges will be met before storage drops below the short UJ route level (75% storage) – at which point batteries will be repurposed for general storage use


DRIVING
POSITIVE CHANGE


GridCars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Procurement and Operation

- Had extensive presentations to UJ Executive that took 14+ months to get approval to continue with project – fortunate that UJ solar PV paved the way ito sustainability projects with RoIs better than bank returns
- Procured first buses in 2021/2
  - 2 EV buses for circular routes
  - 1 EV bus for shuttle use
- Before delivery had access to a demonstration bus for 3 months
- Took delivery and trialed for 2 weeks
- Installed 2 charging stations
  - 1 at the overnight depot
  - 1 at SW Muller stadium on APB campus
- Ran 2 circular route buses for 6 months on the shorter APK – APB – APK route while we became comfortable with operations and risk
- Students are wildly appreciative – can see this on Twitter / Instagram

Actual Performance to Date

- 3 EV buses – > 250 000km in actual operation
  - Transported more than 300 000 students in past 18 months
  - Energy use per km – 1.55-1.75 kWh/km (depends on route) (R2.20-2.75/km)
  - Maintenance costs per km – < R1.00 / km
  - Mechanical incidents – zero
  - Range incidents – zero

- Charging stations are performing well and are even considerin opening them for UJ staff with battery electric cars

EV and H2 Bussing Review

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EV vs H2 Bussing

- EV bussing not popular in USA far north (UIUC) – more popular in south (UT Waco) because of temperature impact on batteries
- H2 bussing is growing – saw trial busses in multiple places – UIUC MTD are busy with first 22 H2 buses of the fleet of 120 buses – aim is to have only H2 buses by 2030
- H2 buses in US cost USD2.15m EACH! (EV bus cost USD1.0m vs SA ZAR 6.5m – USD55k)
- The UIUC routes compared to UJ routes
  - Average inter-stop distance 900m rather than multi-km distances at UJ
  - Buses generally do more than 350 km / day – H2 buses have 650 km ranges rather than 320 km range for UJ EV buses
  - UIUC use standing only buses (100+ per bus like airport shuttles) because average trip of a passenger is less than 3 stops (3-5min period)

EV / H2 Bussing pt 2

- UIUC MTD H2 fuel cell fuel generation
  - Committed to green H2 only – use power from solar PV farm and “store” in the grid with AmericanEnergy
  - Use electrolysis plant from a German company NEL (1MW continuous)
  - Presently plant is only used at low levels since only 10 buses running but plant can manage all 22 initial buses total fuel requirements
  - Keep plant going at low power even when bleeding excess H2 – thus efficiency issues are a concern
  - Presently pressurized gas H2 storage decouples production from use but this is a real risk
  - Have had some pushback from homeowners near the depot about H2 fire and explosion risk
- Funding – 85% from Federal US Government for both buses and electrolysers!

Carbon

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UJ Carbon Footprint

- Seen as most important single performance index from UJ senior management – even more important than absolute energy (or energy per stakeholder) metrics
- Cars and carbon are bound together in terms of “in-out” commutes as well as bus intercampus transport and are counted towards carbon targets by UJ from 2025!
- Almost 3.8% of UJ total (49 000kg/a) carbon is due to the diesel intercampus bus service
- Reductions for a full EV bus service would be to reduce this to under 0.25%
- Costs / savings of EV bus operation carbon reduction are not used for RoI purposes (at R120/tCO2 this is not presently so important)

Thank you

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