Infrastructure

Rural Feeder Road Upgrading

Policy area nominated by Zambia



Rural Feeder Road Upgrading

- Business as usual:
  - **The road remains rough, slow, and seasonally unreliable**
  - **Traffic grows slowly with local economic activity, but road roughness, slow speeds, high operating costs, and vehicle maintenance costs persist**
  - **Routine grading continues at a low BAU level**
- Policy scenario:
  - **Upgrade 50 km of rural feeder roads with gravel surfacing, drainage, spot improvements, and a funded maintenance plan**
  - **The road opens in 2027 and produces direct user benefits for 15 years.**

What's the value of a better road?

- Additionality rule:
  - **Count only incremental benefits and costs relative to BAU**
  - **Existing users save time and cost**
  - **New traffic is valued less (rule of a half)**
    - New trips are marginal – only just worth it now thanks to improvements
  - **Broader agricultural, health, education, land-value, and market-access benefits are discussed but not included without separate source-backed effect models**

How the benefits were calculated

- Step 1: Estimate time saved
  - **Time before 30 km ÷ 22 km/h = 1.36 hours**
  - **Time after 30 km ÷ 45 km/h = 0.67 hours**
  - **Time saving = 0.70 hours per trip**
- Step 2: Calculate value of time and costs savings per vehicle trip
  - **Value of time saved = S$2.26**
  - **Transport operating saving = $3.00**
  - **Vehicle maintenance saving =$2.40**
  - **Total saving per trip = $7.66**
- Step 3: Scale up to all traffic
  - **Annual existing-user benefit = vehicles per day × 365 days × saving per trip**

How time was valued

- Income proxy for value of people's time
  - **Average rural monthly income / 177 hours = US$0.75**
  - **2 passengers × US$0.75 per passenger-hour = US$1.50**
  - **0.7 hour saved x US$1.50 = US$1.05**

Generated traffic and the “rule of a half”

- Better roads encourage trips that were not made before
- The base case estimates:
  - **Existing traffic = 200 vehicles/day**
  - **Assumption 16.7% increase**
  - **Generated traffic = 33.4 vehicles/day**
- Existing road users receive the full benefit (time and cost saving):
  - **Existing-user benefit= existing trips × US$7.66**
- Newly generated trips receive only half the benefit (from 0% to 100%):
  - **Generated-traffic benefit = 50% × new trips × US$7.66**
  - **This prevents the CBA from overstating the value of additional road use**

Benefit-cost ratio is FAIR

- PV benefits
  - **US$7.53m**
- PV costs
  - **US$6.50m**
- BCR = 1.3 FAIR
- The result depends on the road carrying about 200 vehicles/day, speed improving from 22 to 45 km/h, and maintenance being funded after opening

AI exercise: Value of time

Estimate current rural and urban hourly income benchmarks for valuing time

AI exercise

- Participants ask AI to:
  - **Estimate current rural and urban hourly income benchmarks for valuing time**



16:10–16:20 **AI-supported individual exercise**

Estimate current rural and urban hourly income benchmarks for valuing time

Copy value-of-time prompt

Show value-of-time prompt

16:20–16:45 **Electricity grid extension**

15-minute case application followed by audience questions

Extend the national electricity grid to unserved communities

Policy area nominated by Namibia



Electricity access

- Business as usual:
  - **Households, firms, schools, clinics, and water points continue relying on kerosene, diesel generators, phone-charging services, limited solar devices, or no electricity service**
- Grid extension example:
  - **connect 10,000 household-equivalent users through national electricity infrastructure**
  - **600 kWh per connection-year**
  - **an evening-heavy demand profile**
    - households prioritize nighttime electricity while SMEs value daytime electricity more strongly
  - **peak load equal to 2.8 times average load**
- Solar-storage example:
  - **provide the same electricity service using local solar PV, batteries, and mini-grid distribution**

Modern electricity access CBA results

Scenario	Grid BCR	Solar-storage BCR	Least-cost option	Key lesson
Remote low-use tranche 4 GWh	**0.3**	**0.5**	Solar-storage	Neither option pays if demand is weak and grid distance is long.
Base dispersed-community tranche 6 GWh	**0.9**	**1.0**	Solar-storage	Solar-storage is the better base-case option.
Productive-load cluster near grid 9Gwh	**2.3**	**1.9**	Grid extension	Grid wins when communities are closer and demand is higher.

How benefits were calculated

- Annual electricity service benefit
  - **delivered kWh × economic value per kWh**
  - **6,000,000 kWh/year × N$6/kWh = N$36.0m/year**
    - N$6/kWh is above retail tariff because it represents gross service value, not tariff revenue
    - N$4, N$6, N$8 used to represent weak, moderate, and productive-use demand
  - **PV benefits = N$487.8m**
    - Calculated over 25 years due to the long life-time of investment

How costs were estimated

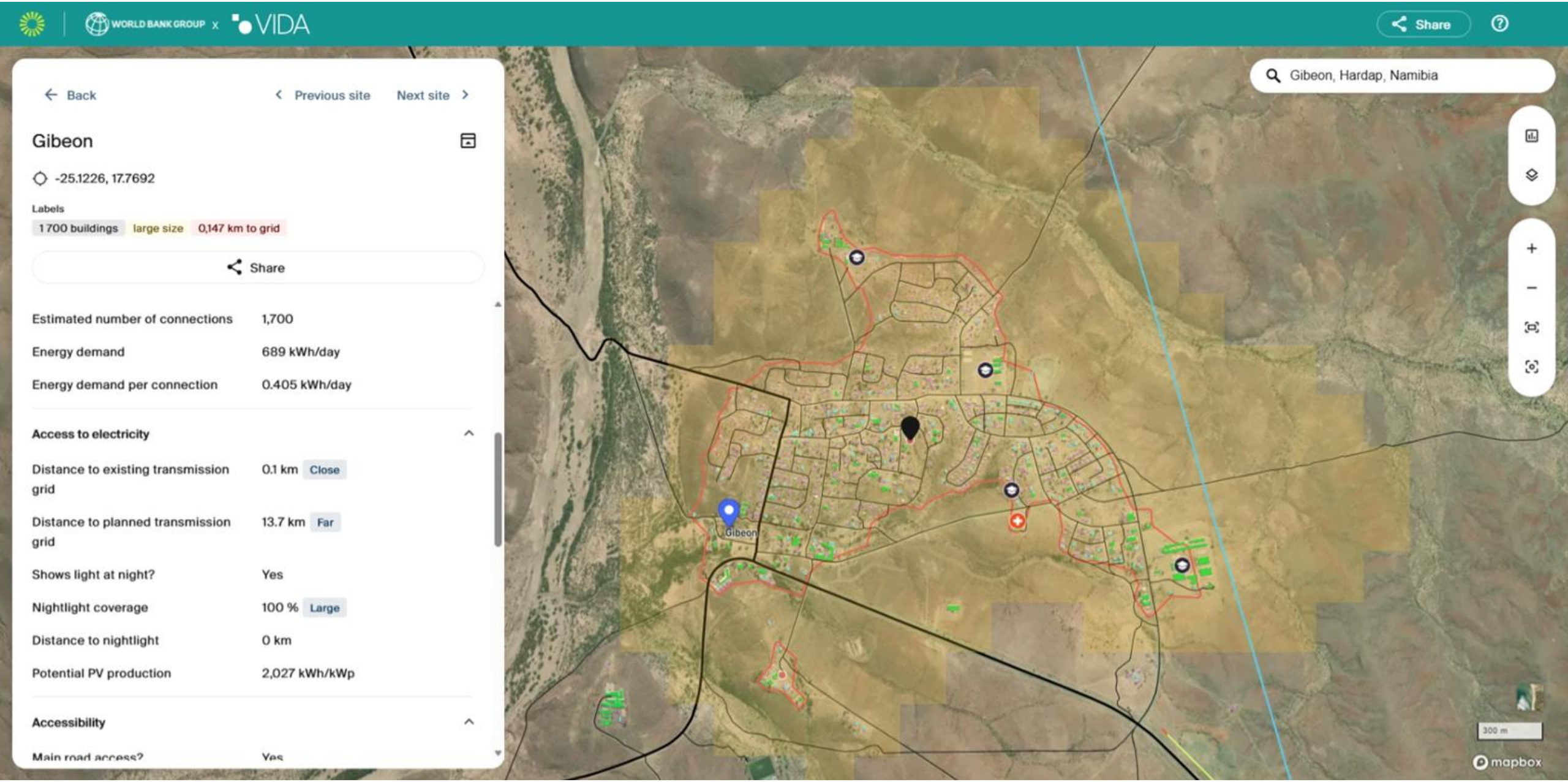
- Grid cost
  - **line extension + connections + transformers = N$350m**
    - Cost not publicly available, assumption N$ 1,000,000/km
  - **purchased energy + O&M = N$16.7m/year**
    - Grid supply cost from Transmission Tariff Schedule 2025-2026 N$1.45/kWh
- Solar-storage cost (before reliability test)
  - **PV capacity + battery capacity + mini-grid network = N$297m**
    - PV and BESS unit costs are anchored to NamPower project estimates
  - **O&M = N$6.2m/year**
  - **Battery /inverter replacements**
    - Battery N$58.8m every 10 year, inverter N$11.3m every 15 year, PV no replacement

Battery storage tested for reliabilty

- Solar-storage alternative stress-test
  - **Against a representative hourly dispatch screen: NASA POWER 2021-2025 hourly solar data averaged across northern, central, and southern Namibia proxy points**
  - **Paired with the evening-heavy daily load profile, hourly loads not yet known**
- Outages from battery depletion
  - **875 hours/year**
  - **272 events/year**
- 99.5% hourly availability
  - **0.7 MW extra PV and 1.1 MWh extra battery**
  - **Results in 43 outage hours and 21 events/year**
  - **Adds N$ 20.3m in capital cost**

Training takeaways

- The decision turns mainly on distance to grid, demand level, productive use, service value per kWh, PV/battery costs, and O&M assumptions
- Each community has an individual
  - **cost profile (geolocation, existing infrastructure)**
  - **benefit profile (electricity demand, demography, economy)**
  - **BCR**
- World Bank Global Electrification Platform
  - **Open data model supporting least-cost energy planning**


WORLD BANK GROUP x VIDA
Share
Back
Previous site
Next site
Gibeon
-25.1226, 17.7692
Labels
1 700 buildings
large size
0,147 km to grid
Share
Estimated number of connections 1,700
Energy demand 689 kWh/day
Energy demand per connection 0.405 kWh/day
Access to electricity
Distance to existing transmission grid 0.1 km Close
Distance to planned transmission grid 13.7 km Far
Shows light at night? Yes
Nightlight coverage 100 % Large
Distance to nightlight 0 km
Potential PV production 2,027 kWh/kWp
Accessibility
Main road access? Yes
Gibeon, Hardap, Namibia
Gibeon
300 m
mapbox