



جامعة عجمان
AJMAN UNIVERSITY

SMART SOLAR PEDESTRIAN NODES (SSPN)

Feasibility Study & Technical Proposal

Converting Pedestrian Wait Time Infrastructure into Distributed Clean Energy and Smart Mobility Assets

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Innovative Category

NextGen for Mobility Award

For our Dubai-it

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1. Executive Summary & Technical Architecture

1.1 Concept Overview

Every signal controlled pedestrian crossing in Dubai currently represents unused real estate: a fixed structure that exists solely to hold a push button and a countdown display, generating no energy, collecting no usable data, and offering no protection from a climate that exceeds 45°C for roughly four months of the year. Smart Solar Pedestrian Nodes (SSPN) repurpose this footprint into a self powered, sensing, and shading unit that generates electricity from the same sun pedestrians are hiding from, harvests water from ambient humidity to clean itself without a maintenance truck roll, senses crowd behavior with on device AI instead of uploading video, and gives People of Determination (POD) automatic priority without requiring them to locate or reach a button.

The unit is engineered as a retrofit: it bolts onto or replaces the existing RTA pedestrian signal post/canopy footprint at grade separated and at grade crossings alike, requiring no new civil footprint beyond the existing pole base.

1.2 Physical Infrastructure Layer

- **Solar PV Canopy:** bifacial monocrystalline panels (capturing reflected pavement radiation, a known yield gain in high albedo desert deployments) mounted as a cantilevered shade structure over the pedestrian standing zone. Sized to fully shade the waiting area at peak summer sun angles, and to run net positive against the node's own signal, lighting, sensor, and AWG load, with surplus exported through a standard grid tie inverter to the local low voltage network or an adjacent RTA asset (bus shelter lighting, CCTV pole, EV charger).
- **Atmospheric Water Generation (AWG):** a compact Peltier or desiccant wheel unit sized for an auxiliary, not primary, role. It condenses water from the elevated night time and winter humidity typical of the Gulf coastal climate, for two closed loop uses:
 - (1) low pressure spray cleaning of the PV surface dust soiling, not heat, is the largest controllable driver of desert PV yield loss, so this recovers generation the canopy would otherwise lose.
 - (2) drip irrigation for the streetscape planting RTA already installs at many crossings under the Dubai 2040 walkability agenda.
- **Structural Note:** this pairing is deliberate, not decorative. AWG condensation improves with night time radiative cooling, and unmanaged PV soiling in Dubai's dust conditions can cost meaningful annual yield so the two systems close a maintenance loop for each other rather than existing as two unrelated add ons competing for canopy space.



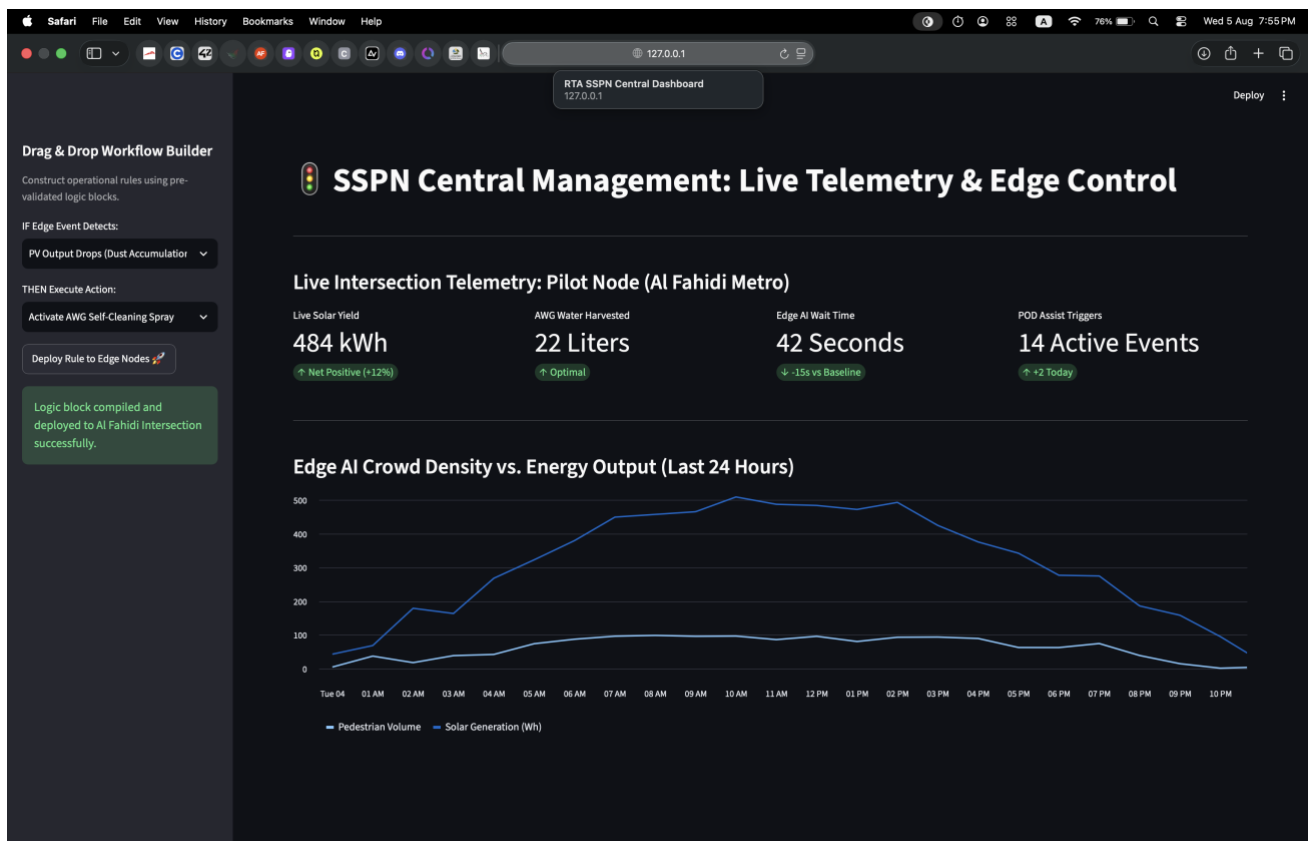
Note: This image AI generated to give you imagination about the idea.

1.3 Software & Intelligence Layer — Edge AI

- **Local, not cloud, vision processing:** each node runs a Python based computer vision stack (OpenCV plus a lightweight, quantized object detection model such as a distilled YOLO variant) on an on pole edge accelerator (e.g., a Coral TPU or Jetson class module). Frames are processed and discarded on device no continuous video stream ever leaves the pole. The node outputs only structured, anonymized events: a person count, a wait time estimate, a mobility aid flag never raw imagery.
- **Crowd density and wait time logic:** the model estimates how many pedestrians are queued and adjusts, within RTA's existing signal timing safety envelope, how assertively that crossing requests priority in the controller's cycle busy crossings are called more aggressively, empty ones do not waste a phase.
- **Why edge, not central, compute:** running inference at the pole rather than streaming to a server is what makes hundreds of intersections viable simultaneously it removes both the bandwidth bottleneck and the video storage/privacy liability that centralized capture across an entire city's crossings would otherwise create, this what I learned from e& Afaaq programme.

1.4 RTA Central Management Dashboard

- Operators do not configure this fleet through free text, a command line, or spreadsheets. The dashboard is a **button only, drag and drop workflow builder**: an operator creating a rule for example, “if POD flag detected → extend green phase by X seconds,” or “if AWG tank level < 20% → raise maintenance ticket” assembles it by dragging pre validated logic blocks onto a canvas and wiring them together, the way a control room technician would wire a physical panel.
- This is an operational safety decision, not a UX preference: free text fields are where operator typos become live traffic signal misconfigurations. Removing text entry from the live configuration surface removes an entire class of human error from a system that touches pedestrian safety, without requiring every control room shift to include someone who can write code.
- The same block based canvas surfaces live per node telemetry energy generated versus consumed, water harvested, crowd counts, POD trigger frequency, uptime so diagnosing a fault is drag and inspect, not log parsing.



Note: I made this dashboard to mimic the real system at the future.

1.5 Future Proofing: UAV Docking Provision

- The canopy frame is deliberately over specified from day one for a secondary load case: a small class UAV docking and charging pad (inductive or contact) on the non PV upper surface or an integrated edge mount. This adds marginal cost in steel/aluminum section sizing at construction far cheaper to build in now than retrofit later and positions the node fleet as ready made infrastructure for RTA's stated interest in autonomous aerial logistics and inspection drones, without committing the pilot budget to drone hardware itself.

2. Implementation Plan & Feasibility (Pilot Phase)

2.1 Pilot Site Selection Criteria

Candidate intersections should be scored against four criteria:

- (1) documented high pedestrian volume tied to a transit transfer point (metro/bus interchange).
- (2) direct summer sun exposure with no adjacent tall building shading, to maximize PV yield.
- (3) proximity to a labor accommodation, industrial zone, or low income worker commute route, to maximize the safety case.
- (4) existing RTA power/fiber infrastructure at the pole, to minimize new trenching cost.

A crossing feeding a high footfall Dubai Metro station adjacent to a bus interchange for example, in the vicinity of a Red Line station serving a dense residential and labor catchment such as Al Fahidi, Baniyas, or Ghubaiba matches this profile and is proposed as the representative pilot typology. The final site should be confirmed jointly with RTA Traffic Engineering and Smart Dubai using RTA's own footfall counts, since RTA already holds better ground truth pedestrian data than any external estimate this proposal could produce.

2.2 Phased Rollout

- **Phase 0 (Weeks 1–4):** structural and electrical design sign off with an RTA approved consultant; site survey of the selected pilot crossing.
- **Phase 1 (Months 1–3):** single-node deployment at the pilot crossing, wired for grid export and instrumented for full telemetry logging from day one.
- **Phase 2 (Months 3–6):** data collection and model tuning window the crowd density and POD detection models are calibrated against real local pedestrian behavior and lighting conditions rather than a generic public dataset.
- **Phase 3 (Months 6–9):** controlled comparison against one to two untouched control crossings of similar footfall, to isolate the node's actual effect on wait-compliance and signal-request accuracy before any city wide business case is written.
- **Phase 4 (Month 9+):** go/no go decision gate for corridor level rollout typically 8–12 nodes along a single BRT or metro feeder corridor based on Phase 3 data.

2.3 Feasibility & ROI Framework

The methodologically honest approach for a first of kind pilot is not to publish one static payback figure: no external party has RTA's real per kWh export tariff, real installed cost at fleet procurement scale, or real maintenance crew hourly cost, so a fixed number would be presentation rather than analysis. Instead, the node is designed so that every input to the ROI equation is a live, logged variable from the day it is switched on.

- **Energy side:** the dashboard logs generated kWh, self consumed kWh (signal, lighting, sensors, AWG), and exported kWh separately, in real time, per node producing an actual offset versus tariff and grid feed in figure within one full seasonal cycle, which matters in Dubai since summer generation and summer load both peak together.
- **Cost side:** bill of materials cost, installation labor, and the AWG driven maintenance saving (fewer manual panel cleaning callouts, tracked against whatever PV/solar shade maintenance baseline RTA already runs elsewhere in its network) are logged as actuals once the pilot exists, not estimated in advance.
- **Decision gate:** the resulting payback period and levelized cost per node are computed from the pilot's own operating data at the Phase 3 gate not asserted in this document. The live dashboard itself is the evidence artifact presented to the judges as the ROI methodology, in place of a static mock figure.
- **Directional basis only:** distributed generation feeding directly into local low voltage infrastructure avoids most of the transmission and distribution loss that centrally generated grid power incurs traveling across the

city a structural reason to expect a positive case. The pilot's role is to size that advantage with real data, not to assume it.

2.4 Risk Assessment

- **Technical:** dust accumulation between AWG cleaning cycles mitigated by tank level triggered cleaning rather than a fixed schedule; POD detection false positive/negative rates during early tuning mitigated by the Phase 2 calibration window and a manual push button retained in parallel at all times.
- **Operational:** dashboard rule misconfiguration mitigated structurally by the button only builder itself, plus a staged approval step before any rule goes live in the field.
- **Financial:** PV/AWG component cost volatility mitigated by committing to single node pilot sizing before any bulk procurement decision.

3. Alignment with Dubai Standards

3.1 Dubai 2040 Urban Master Plan

The plan's core structural shift is toward five minute city walkability and a substantial expansion of public, green, and recreational space allocation across Dubai's urban fabric. A pedestrian crossing that only holds a person for 60-90 seconds in open sun works against that intent in practice, regardless of the design goal on paper. SSPN is a direct, low footprint retrofit that brings the existing crossing network into line with the plan's density and walkability targets immediately, rather than waiting on the larger urban redesign projects the plan describes over its 2040 horizon.

3.2 Dubai Clean Energy Strategy 2050

The Strategy's headline target is 75% clean energy in Dubai's power mix by 2050, delivered partly through utility scale sources such as the Mohammed bin Rashid Al Maktoum Solar Park, and partly through distributed generation. SSPN sits directly in the distributed generation category the Strategy calls for alongside utility scale build out: thousands of small, grid tied generation points spread across load centers rather than one more centralized plant plus a water angle (AWG) a solar park does not offer, connecting the Clean Energy Strategy to Dubai's parallel water security agenda.

3.3 RTA Smart Transport Objectives & Vision Zero

You Guys, RTA's own strategic pillars Smart Transport digitization and the Vision Zero goal of eliminating traffic fatalities are both served directly. Smart Transport, because each node is a new, real time, structured data source about pedestrian behavior that RTA does not currently hold at signal level. Vision Zero, because automatic POD detection and crowd adaptive phase timing address two of the most common pedestrian safety failure modes at a signalized crossing: a vulnerable user unable to reach or operate the button in time, and a signal phase too short for the actual number of people crossing.

4. Community Inclusivity & Social Impact

4.1 Protecting Vulnerable Demographics

Dubai's own municipal heat safety framework restricts outdoor manual labor during the hottest midday hours for exactly the population most likely to be standing at these crossings outside those restricted hours too: construction and industrial workers commuting to and from labor accommodation, alongside students and lower income transit dependent commuters without access to a private, air conditioned vehicle. These groups currently wait for their signal phase in direct sun at precisely the crossings closest to industrial areas and labor accommodation which is exactly where the pilot site selection criteria in Section 2.1 point. Shade is not a comfort feature for this group; it is a direct reduction in heat stress exposure for the population with the least ability to avoid it.

4.2 People of Determination (POD) Integration

- The same edge computer vision model used for crowd counting is trained to recognize the visual signature of a wheelchair and a white cane within the camera's field of view.
- On a positive detection, the node automatically extends the green pedestrian phase, within RTA's approved timing envelope, rather than waiting for a manual push button interaction.
- This removes two real barriers at once: physically reaching or locating a button from a wheelchair or without sight, and the timing burden of correctly triggering it before the phase would otherwise begin. The manual button remains in place as a fallback and redundant trigger automatic detection is additive to, never a replacement for, existing accessible crossing hardware, so the system fails safe to the current standard if a detection is ever missed.

4.3 Broader Social Return

Beyond the direct beneficiaries at each node, fleet wide telemetry footfall, wait time, POD trigger frequency, by location gives RTA a city wide, privacy preserving dataset on where accessibility demand and heat exposure risk actually concentrate, turning a piece of shading infrastructure into a planning input for where the next accessible crossing or shaded corridor investment should go.

5. Conclusion & Technical Summary

SSPN does not ask RTA to build a new category of asset from nothing it asks RTA to make an asset it already owns at every signalized crossing in the city do more work: shade instead of just standing, generate instead of just consuming, sense instead of just displaying a countdown, and extend priority automatically instead of waiting for a button to be found and pressed. The pilot structure in Section 2 is deliberately conservative one node, one seasonal cycle, real telemetry, a genuine control group comparison so that the go/no go decision for a corridor scale rollout is made on the node's own operating data, not on a proposal's projections.

Appendix A — Component / Function / Technology Summary

Component	Function	Core Technology
Solar PV Canopy	Shade + grid tied power generation	Bifacial monocrystalline PV, grid tie inverter
AWG Unit	Panel self cleaning + irrigation water	Peltier / desiccant wheel condensation
Edge AI Vision	Crowd density, wait time, POD detection	Python (OpenCV), quantized on device CV model
Signal Interface	Adaptive phase timing requests	Edge output → existing RTA controller, within approved envelope
Central Dashboard	Fleet monitoring & rule configuration	Button only, drag and drop workflow builder
UAV Docking Provision	Future aerial logistics/inspection support	Reinforced structural frame, inductive/contact pad