



Whitewell NPP - Bulgaria - Germany transmission corridor (demonstration)

Demonstration project (generated with WaiMAP engines)

Document no.	WMAP-DEMO-TRANSM-20261013
Revision	A
Status	Demonstration -- not for construction or investment decisions
Design status	Concept
Approval status	Pre-feasibility only
Report level	Demonstration -- sample report
Date of issue	2026-10-13
Project	Whitewell NPP - Bulgaria - Germany transmission corridor (demonstration)
Location	Whitewell NPP area -> Bulgaria -> Bavaria (Germany)
Coordinates (WGS84)	A 37.05, 35.45 · W 42.25, 25.65 · B 48.70, 11.60
Scope	400 kV corridor screening, representative sections
Prepared for	Public demonstration (no client)
Prepared by	WaiMAP - Spatial Intelligence
Data basis	Open atlas data (GHSL, JRC, GSA) · WaiMAP engines

Revision history

Rev	Date	Description	Prepared	Checked	Approved
A	2026-10-13	Demonstration issue	WaiMAP engines	--	--

Public demonstration · Demonstration -- not for construction or investment decisions

Demonstration project (generated with WaiMAP engines). Generated from open data with the WaiMAP engines to show the workflow and the method. It is not a study of a real project, makes no statement about any real project, and does not replace site surveys, detailed design, permits or independent review. WaiMAP does not guarantee lender or independent-engineer approval.



Whitewell NPP - Bulgaria - Germany transmission corridor (demonstration)

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1 Purpose and scope

Corridor screening for a 400 kV overhead line of about 2,418 km from the Whitewell NPP area via Bulgaria to Bavaria: route alternatives on an open-data cost surface, three representative 10 km sections with tower spotting, sag-tension, quantities, optimum spotting and checks. Demonstration project (generated with WaiMAP engines).

2 Cost surface from open data

Engine: build_demos.py -> WaiLineMech land classes

Method: EPSG:3035 grid, 2 km cells, $1284 \times 1091 = 1,400,844$ cells. Classes: open water where the Global Solar Atlas has no land data ($\times 15$), dense built-up $\geq 25\%$ (exclusion), settled (built-up $\geq 5\%$ or ≥ 400 persons/km², $\times 40$), flood-prone (RP100 mean depth ≥ 0.3 m over the cell, $\times 3$), open ($\times 1$) -- the ohl400 weights of WaiLineMech.

o Share of cells: water 27.35 %, settled 3.85 %, dense built-up 0.19 %, flood-prone 17.57 %

o Not in this surface: slope (no DEM), protected areas, forests, road / rail / river / power-line crossings (OpenStreetMap) -- they are added in the app

3 Route alternatives

Engine: WaiLineMech.routeAll (A* on 16 neighbours, penalised re-runs)

Method: Two legs (A -> W, W -> B) with the waypoint in Bulgaria; per leg: cheapest, least sensitive (land weights cubed) and shortest; alternatives separated by ≥ 15 km.

o Cheapest: 2,418 km ($\times 1.046$ of straight line), settled 34 km, flood-prone 122 km, water 2 km, 60 angle points

o Least sensitive: 2,703 km ($\times 1.169$ of straight line), settled 17 km, flood-prone 80 km, water 6 km, 61 angle points

o Shortest: 2,330 km ($\times 1.008$ of straight line), settled 108 km, flood-prone 479 km, water 40 km, 3 angle points

4 Representative sections -- spotting and sag-tension

Engine: WaiLineMech.design (IEC 60826 / EN 50341-1 style cases, CIGRE TB 324 change of state)

Method: Three 10 km sections of the cheapest route, each starting 3 km before an angle point of the route (rule fixed before the run); 400 kV single circuit, triple ACSR Cardinal, 2 OPGW, medium soil. Angle points from the route geometry. Terrain profile: level ground (no DEM on the build machine -- in the app the profile comes from the DEM / LiDAR).

o Section 1 -- Southern Türkiye: 26 towers, mean span 400 m, 393.9 t steel, ruling span 375 m, EDS 20 % RTS, sag at max. temperature 13.53 m; checks: Ground and crossing clearance PASS, Maximum working tension PASS, Aeolian vibration (H/w) WARNING, Tower spotting PASS, Uplift PASS

o Section 2 -- Bulgaria: 26 towers, mean span 400 m, 387.4 t steel, ruling span 375 m, EDS 20 % RTS, sag at max. temperature 13.53 m; checks: Ground and crossing clearance PASS, Maximum working tension PASS, Aeolian vibration (H/w) WARNING, Tower spotting PASS, Uplift PASS

o Section 3 -- Southern Germany (Bavaria): 26 towers, mean span 400 m, 393.9 t steel, ruling span 375 m, EDS 20 % RTS, sag at max. temperature 13.53 m; checks: Ground and crossing clearance PASS, Maximum working tension PASS, Aeolian vibration (H/w) WARNING, Tower spotting PASS, Uplift PASS

5 Optimum tower spotting

Engine: WaiLineMech.optimise (dynamic programming, Mitra & Wolfenden formulation)
Method: Candidate stations every 25 m, tower types × body / leg extensions, exact weight / wind spans, clearance per tension section; objective = steel + erection + foundation (region unit rates of the engine).
o Section 1 -- Southern Türkiye: simple spotting 26 towers / USD 1,166,555 -> optimum 24 towers / USD 1,101,104 (5.61 %)
o Section 2 -- Bulgaria: simple spotting 26 towers / USD 2,031,932 -> optimum 24 towers / USD 1,916,017 (5.70 %)
o Section 3 -- Southern Germany (Bavaria): simple spotting 26 towers / USD 2,066,025 -> optimum 24 towers / USD 1,950,110 (5.61 %)

6 Quantities and cost (screening)

Engine: WaiLineMech quantities + per-km cost model (lineCost, indicative EU defaults)
Method: Section quantities per km × the route length (extrapolation -- stated, not a full-length spotting). Per-km line cost: the engine's indicative screening defaults; no crossings counted (no OpenStreetMap).
o Extrapolated for 2,418 km: ~ 6,288 towers, 94,737 t tower steel, 151,553 m³ foundation concrete, 40,605 t conductor, 21,040 insulator sets
o Indicative line cost of the alternatives (engine per-km defaults): Cheapest USD 2,044 million; Least sensitive USD 2,284 million; Shortest USD 1,969 million

7 Checks and warnings

Engine: WaiLineMech checks
Method: Clearance, maximum working tension, aeolian vibration (H/w, CIGRE TB 273), spotting, uplift -- per section.
o Aeolian vibration (H/w): WARNING -- 2 section(s) above the CIGRE TB 273 undamped limit 1125 m -- specify vibration dampers

8 Access roads and crossings

Engine: Corridor routing with OpenStreetMap, Logistics (in the app)
Method: Road / rail / river / power-line crossings, access tracks and abnormal-load routes need OpenStreetMap and a routing service -- not available on the build machine.
o In WaiMAP: Line routing & mechanics -> route -> crossings and access estimate; Logistics -> abnormal-load check for transformers and tower sections.

9 Route alternatives

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Alternative	Length (km)	× straight line	Settled (km)	Flood-prone (km)	Water (km)	Angle points	Indicative cost (USD million)
Cheapest	2,418	1.046	34	122	2	60	2,044
Least sensitive	2,703	1.169	17	80	6	61	2,284
Shortest	2,330	1.008	108	479	40	3	1,969

10 Representative sections -- design

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Section	Start (km)	Towers	Mean span (m)	Steel (t)	Concrete (m³)	Conductor (t)	Insulator sets
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Section 1 -- Southern Türkiye	29.8	26	400	393.9	630	167.9	87
Section 2 -- Bulgaria	1124.6	26	400	387.4	620	167.9	87
Section 3 -- Southern Germany (Bavaria)	2365.4	26	400	393.9	630	167.9	87

11 Sag-tension (section 1, ruling span)

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Case	°C	H initial (kN)	% RTS initial	Sag final (m)	Swing (°)
Everyday stress (EDS)	15	30.02	20.1	11.12	0
Minimum temperature	-20	34.92	23.4	9.68	0
Extreme wind	10	56.09	37.7	12.42	61.8
Ice (radial 6 mm, 900 kg/m³)	-5	41.07	27.5	10.86	0
Ice + reduced wind	-5	49.4	33.1	11.37	37.9
Maximum operating temperature	80	24.29	16.3	13.53	0

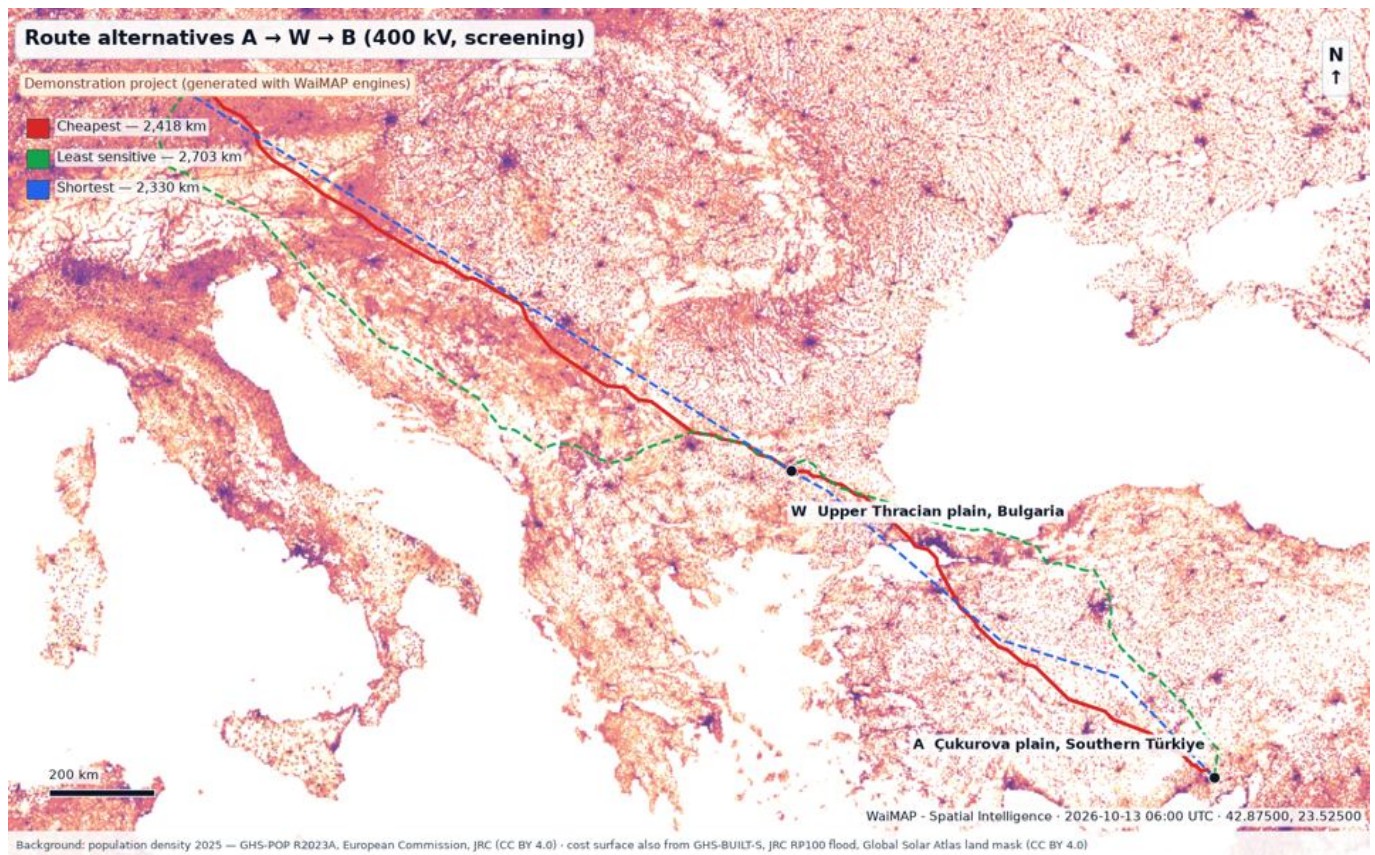
12 Tower spotting -- baseline vs optimised (potential savings)

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Section	Region rates	Towers (simple)	Towers (optimum)	Simple (USD)	Optimum (USD)	Saving (USD)	Saving (%)
Section 1 -- Southern Türkiye	TR	26	24	1,166,555	1,101,104	65,451	5.61
Section 2 -- Bulgaria	EU	26	24	2,031,932	1,916,017	115,915	5.70
Section 3 -- Southern Germany (Bavaria)	EU	26	24	2,066,025	1,950,110	115,915	5.61
Total of the three sections				5,264,512	4,967,231	297,281	5.65

13 Route alternatives map

Three route alternatives from the WaiLineMech least-cost engine (A*, 16 neighbours) on a 2 km cost surface built from settlement, flood and water data.



14 Potential savings -- method and scope

- o Scope: Tower spotting on the three representative 10 km sections (30 km of the 2,418 km route): tower steel, erection and foundations.
- o Baseline: WaiLineMech simple spotting (equal target spans, angle points from the route)
- o Optimised: WaiLineMech optimum spotting (dynamic programming over candidate stations every 25 m)
- o Price date: WaiMAP indicative unit rates, 2026 (steel USD 2200/t, erection USD 420/t, concrete USD 180/m³ -- EU region; TR section with the TR rates)
- o Exclusions: Conductor, insulators, OPGW, land / right of way, access roads, crossings, substations, engineering, permits, financing; terrain effects (level ground).
- o Constraints: Same conductor, clearance, tension limits, tower family limits and angle points in both cases; no clearance violations in either.

Potential savings in the three sections: USD 297,281 (5.65 %). Same sections with the angle point moved to mid-section (5.0 km): Section 1 0.00 %; Section 2 0.00 %; Section 3 0.00 %. The saving depends on the geometry -- where equal spans already fit, simple spotting is optimal. Verified savings: no verified project comparison published yet.

15 Warnings and limitations

- o Full-length spotting was not run: three representative 10 km sections were computed and their per-km quantities extrapolated (stated wherever used).
- o Level-ground profile in the sections (no DEM on the build machine): real terrain changes spans, extensions and tower counts.
- o The cost surface has no slope, protected areas, forests or OpenStreetMap crossings; routes are corridor screening, not alignments.
- o Crossing the Turkish Straits region: the cheapest route crosses open water (water km in the table) -- a submarine cable or long-span crossing needs its own study.
- o Cross-border interconnection needs both TSOs, ENTSO-E planning and permits; none of this is assessed here.

o Unit rates are the engine's indicative 2026 screening defaults (region factors), not quotes.

16 How this demonstration was made

Generated on 2026-10-13 06:00 UTC by tools/demos/build_demos.py with the WaiMAP engines on Intel(R) Xeon(R) Processor @ 2.10GHz (2 cores). Engine computation time for the whole story: 17.6 s.