T4.1: User manual

Tool: Toola — T4.1 Software Tool for Optimising the Energy Chain and Battery Storage Planning

Project: FlexRICAN (GA No. 101131516)

Document version: 1.1

Date: 29 October 2026

UI language: English (field names in this manual match the interface)

1. Purpose

T4.1 is the **electrical energy chain** module in Toola (Step 2 tile T4.1 – Software Tool for Optimising the Energy Chain and Battery Storage Planning). It provides a screening-level assessment of a research infrastructure's electrical supply chain: the public grid, solar PV, wind, CHP, standby diesel and battery storage.

Outputs are annual energy and carbon balances, self-sufficiency indicators, backup validation, lifecycle CO_2, indicative CAPEX/O&M, and exports for further use.

The tool is a **screening** instrument. It does not replace hourly dispatch, a grid study, detailed design, UPS specification, procurement or a certified LCA.

2. Intended users

facility and energy managers of research infrastructures,
sustainability / reporting teams,
planners comparing supply and backup options on a horizon to 2055.

3. Scope

In scope	Out of scope
Annual electrical demand (Level 3)	Hourly coincidence of generation and load
On-site PV, wind and CHP output	Grid export and feed-in
Grid import and self-sufficiency	Electricity prices, tariffs, VAT, financing
Operational CO_2 (grid, CHP, diesel)	Marginal hourly grid intensity
Battery / diesel backup sizing and validation (MET / UNMET)	SOC, degradation, protection, fire requirements
Indicative CAPEX, O&M, embodied CO_2	Full OPEX, connection, construction costs
PECD 4.2 climate projections to 2055	Weather forecasts or on-site measurements

HVAC (T7.2) is an optional module in the same workflow. This manual covers the electrical chain. Step 1 is shared.

4. Getting started

Open Toola in a browser.
In production, pass the access gate (magic link). Locally (`localhost` / `file:`) the gate is skipped.
On the landing page click **Start Toola Assessment**.
A five-step wizard opens: Project Context → Facility Ops → Energy Mix → CO2 Balance → Result. The step indicators at the top (sticky while scrolling) jump between steps.

The header links **Methodology** (module methodologies and data sources) and **User Manuals** (this document and the T7.2 manual) are available at any time.

The session is stored in the browser (`localStorage`). Projects are not stored on the server. To move a case between devices, use **Download Config (JSON)** in Step 5 and **Import Config (JSON)** (bottom bar) on the other device.

Clear inputs returns to Step 1 and **permanently deletes** the session data.

5. Shared Step 1 — Project Context

Step 1 is shared by T4.1 and T7.2. It sets the climate and grid data for the whole calculation.

5.1 Technology preferences

Three sliders (0–100, default 50):

CO_2 friendliness (eco) — Carbon-agnostic ↔ Greenest,
Investment cost (CAPEX) — Budget flexible ↔ Minimise CAPEX,
Technology stance — Conservative ↔ Liberal (proven vs. newer technologies).

They steer the backup proposal (Step 2 → 3), the Battery Advisor and the ranking of architecture recommendations in Step 5. **They do not change the energy-balance equations.**

5.2 Time horizon

Field	Meaning	Constraint
Project Start Year	Project start; climate baseline	2026–2054
Project End Year (Max 2055)	End of the assessment horizon	max. 2055, must be > start

5.3 Location and scenario

Field	Meaning
Country / Region	29 countries (EU27 + UK + CH). Sets the national mix and grid emission intensity.
Socio-Economic Scenario	SSP2-4.5 / SSP3-7.0 / SSP5-8.5. Changes **only the climate projections** (SPV/WON yield and the HVAC temperature outlook). Grid intensity, demand and costs do not depend on the SSP.
Facility Coordinates	WGS84. Click the map, or paste coordinates (`50.0755, 14.4378`, whitespace-separated, or with N/S/E/W suffixes) and press **Apply** or Enter.

The country and marker update automatically when the map is clicked or coordinates are applied.

5.4 What happens on Next Step

The browser posts `{ lat, lon, country }` to the Location API. The response contains PECD 4.2 climate records, the P2ON wind region, an optional `fallback_report` (nearest-neighbour fallback), and Ember 2025 mix/intensity. Data stay in the session; a page reload does not call the API again.

Without a successful SPV/WON load, PV and wind output are not calculated. Mix and grid intensity then fall back to the static country table (then 300 gCO_2/kWh if that is also missing — flagged in Step 4).

The T4.1 climate **data query** that drives generation is SPV (PV capacity factor on the 0.25° grid) and WON (onshore wind capacity factor on the P2ON region). Temperature from the same API is used by T7.2, not as a second multiplier on PV/wind.

6. Step 2 — Assessment Scope and Operational Power Profile

6.1 Module selection

Tiles at the top of Step 2 (**Assessment Scope**):

T4.1 – Software Tool for Optimising the Energy Chain and Battery Storage Planning — on by default,
T7.2 – Cleanroom-Oriented Technological Chain Optimization Tool — optional (HVAC).

Choices: Electrical only, Electrical + HVAC, HVAC only. At least one module must be on. A badge next to the heading shows the active mode.

When both modules are on, Steps 2–5 show **Electrical** / **HVAC** tabs.

6.2 Facility template

Load facility template pre-fills Steps 1–3 (location, load levels, backup requirements and energy mix) from real profiles: ELI Beams – Dolní Břežany, ELI ALPS – Szeged, EMFL / HFML-FELIX – Nijmegen, ESS Lund. Values remain editable. **— No Template —** + **Apply** clears the loaded profile.

The template is applied in Step 2; Step 3 only shows its status.

6.3 Operational Power Profile

Three nested levels. **Only Level 3 Yearly Consumption enters the annual energy balance.** kW ratings are used for backup sizing and validation.

Level	Typical meaning	Fields
Level 1: Safety	Critical systems, alarms, minimal ventilation	Max Load (kW), Yearly Consumption (MWh)
Level 2: Essential	Cooling, servers, base labs	Max Load (kW), Yearly Consumption (MWh)
Level 3: Full Ops	Lasers, accelerators, full power	Max Load (kW), Yearly Consumption (MWh)

Yearly consumption is entered in **MWh per year** (spaces as thousands separators are accepted, e.g. `10 512`). Do not add the levels together unless the operator confirms they are independent. L3 should represent the facility's total annual consumption.

6.4 Battery storage (backup requirements)

For each level (Safety, Essential, Full Ops):

tick whether it must be backed up (Safety and Essential are ticked by default),
Required autonomy (min) — defaults 480 / 240 / 0 min. Energy needed = Max Load (kW) × autonomy / 60,
No-break (battery bridge) — always enforced for Safety (a diesel genset needs time to start); optional for the other levels.

Diesel start / transfer bridge (min) — default 15 min. Bridge battery energy = level Max Load (kW) × this time.

No battery storage (also available in Step 3) excludes batteries from the whole configuration; the proposal then relies on diesel only.

On entering Step 3 the tool shows a live battery and/or diesel proposal. Click **Use this suggestion** or ignore it and fill sources manually.

7. Step 3 — Energy Mix Configuration

Configure sources. Each type except the grid can have several instances (**+ Add configuration**, remove with ×).

Source	Key fields	Note
Battery storage	Type, kWp (power), kWh, Time (h), covered levels	Any two of kWp / kWh / Time compute the third. Time = kWh × round-trip efficiency ÷ kWp.
National Grid Connection	Connection Capacity (kW), Expected yearly total import (kWh), UPS system installed	Mix and intensity come from Ember / API, not these fields.
Solar PV (FVE)	Type, kWp, Area (m²)	kWp ↔ m² linked via module efficiency. Output = kWp × SPV (10° tilt; 50 % south, 25 % east, 25 % west).
Wind	Type, kWp	Output = kWp × WON (capacity factor), not wind speed.
Cogeneration (CHP)	Type, kWp, Expected daily operation (h)	0–24 h/day; annual full-load hours = h/day × 365 (default 11 h ≈ 4 015 h/yr).
Diesel Generator	Type, kW, Backup h/yr, covered levels	Standby source; not in the local generation mix. Operational CO_2 only for the stated run-hours.

The grid card also shows read-only values: **Total facility yearly consumption** (Level 3 from Step 2) and **Projected yearly import** (L3 + HVAC electricity − PV − wind − CHP; updates as you add sources). **Expected yearly total import** is your own figure for the report; it does not change the balance.

Tick **UPS system installed** if critical circuits are protected by UPS. If unticked, Step 5 shows a UPS Recommendation Notice. Toola does not size UPS systems.

Battery Advisor (button in the battery card) proposes chemistry and size per selected service (problem) and Step 1 preferences. **Apply to Step 3** replaces the existing battery rows.

Reference parameters (CAPEX, O&M, CO_2, efficiency) come from the asset database. They are not a vendor quote.

8. Step 4 — CO_2 Balance & Energy Mix

Shown after calculation. Main blocks:

National Energy Mix — country fuel mix and `Grid intensity` badge (gCO_2/kWh), Ember 2025.
Metrics — Total Annual Demand (base + HVAC), Local Generation, Self-sufficiency (with grid import), CO_2 Savings vs. 100 % grid baseline. P10–P90 ranges are shown where climate data allow.
Energy Supply Breakdown — share of PV, wind, CHP, grid.
Backup Requirement Validation — for each backed-up level: load, required autonomy, available coverage and **MET / UNMET**. Batteries are checked on power and RTE-adjusted energy; diesel on power; no-break levels also need a sufficient bridge battery.
Operational CO_2 — Electrical — capacity, output, intensity and CO_2 by source, plus Operational CO_2 vs 100% grid baseline and CO_2 by source.

The table total is **operational CO_2 = grid import + CHP + standby diesel (+ HVAC fuel if T7.2 is on)**. Solar/wind rows below the total are **avoided-grid credit**; **they are not added to the total**, because displacement is already in the lower import.

The balance is in annual energy (MWh/yr): surplus local generation above demand is **not exported** and receives no CO_2 credit, and grid connection capacity is not a constraint in the calculation.

9. Step 5 — Results

9.1 Tables and notices

Architecture Recommendation — see 9.2.
UPS Recommendation Notice — shown when UPS system installed is unticked.
Climate Development & Projected Impact — SPV, WON, temperature, wind and humidity from start to end year; effect of SPV/WON change on output.
Carbon Overview (per Energy Source) — manufacturing, operation, disposal, CO_2 payback.
Investment Overview — CAPEX, O&M, area, mass. Indicative EUR excluding VAT, connection and financing; not indexed to the project year. O&M is not full OPEX.

Each table has a **CSV** export.

9.2 Architecture recommendations

Deterministic screening prompts, for example: unmet backup, missing backup, surplus / saturated self-sufficiency, residual grid import, declining SPV/WON trends, battery without local generation, oversized battery, CHP dirtier than the grid, excessive diesel runtime, CO_2 payback beyond the project horizon, P10–P90 sensitivity, dominant O&M cost, HVAC heat recovery.

Critical items (e.g. UNMET backup) are always shown and marked; **advisory** items compete for the remaining slots (four in total), ranked by Step 1 preferences. Recommendations are not a design. **Illustrative energy-mix comparison** offers PV/wind mixes with a fixed cap; **Accept and edit Step 3** copies a mix into Step 3 for editing — it is not automatic siting.

If grid intensity or SPV/WON is missing for a configured source, recommendations are blocked and the tool points back to Step 1 data.

9.3 Configuration comparison

Compare Configurations (Step 5 header):

Current session vs JSON — live session (Steps 1–3, HVAC if loaded, current climate/API) against one export, JSON files only (2+) — 2 to 8 exports without a live session.

Import in Compare **does not change** the form. To load a configuration into the form, use **Import Config (JSON)**. A comparison PDF can be downloaded from the result.

9.4 Exports

Export	Where	Content
Download Config (JSON)	Step 5 header	Inputs, assets, HVAC, climate/API snapshot
Download Full Report (PDF)	Step 5 header	Inputs, full climate series, step-by-step calculations, P10/P90 intervals
Electrical methodology PDF / Word	Header → Methodology	T4.1 methodology
Comparison PDF	Compare Configurations	Comparison report
User manuals (PDF)	Header → User Manuals	T4.1 and T7.2 user manuals

When sharing a result, state date, version, coordinates, SSP, horizon, grid-intensity source and selected assets.

10. Recommended workflow

Step 1: preferences, horizon, location, SSP.
Next Step — confirm climate data loaded.
Step 2: T4.1 on; fill L3 MWh (and kW for backup); set backup levels and autonomy.
Step 3: use or edit the backup proposal; add PV / wind / CHP; set UPS.
Step 4: check the balance and **MET / UNMET** backup validation.
Step 5: climate, costs and recommendations.
Export JSON + PDF. For variant B, change inputs and use Compare.

11. Common situations

Situation	Check
PV/wind show 0 MWh	Step 1: coordinates, successful API, fallback; whether kWp is set.
Self-sufficiency 100 %	Annual generation ≥ demand. Not islanded operation.
Backup shows UNMET	Battery kWp below level load, usable kWh (× RTE) below autonomy, diesel kW too low, or missing no-break bridge.
No recommendations	Missing grid intensity or SPV/WON.
Battery “does not generate” energy	Correct — the battery is backup, not an annual generator.
Diesel in the generation mix	Diesel is standby; it is not counted as local generation.
CHP output looks low/high	Check Expected daily operation (h) — annual hours = h/day × 365.
Different country after JSON import	JSON carries its own climate snapshot; Compare uses the snapshot, not the live API.

12. Legal disclaimer

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