

ENERGIANALYSE.DK — Methodology & Data Sources

The authoritative "one truth" for how the pre-feasibility analysis works: the data it pulls, how it models a property, how it sizes the cost-optimal system, the honesty caveats, and the sources behind every number. Generated 2026-10-08 from `docs/METHODOLOGY.md` (regenerate the PDF with `scripts/build_methodology_pdf.py`).

1. Purpose & governing principle

ENERGIANALYSE.DK is a free Danish building **pre-feasibility** tool. The user enters an address; the backend pulls public Danish data, models the property hour-by-hour over a full year, and a **HiGHS MILP sizes the cost-optimal mix** of roof/ground solar PV, battery, heat pump, thermal store, solar-thermal and small wind over **8760 hours** — with realistic incl-VAT economics and a competitive offer. The flow is **Spektrum** (address → instant potential) → **Byg-selv** (interactive builder + energy-balance diagram + verdict) → **Kontakt / the emailed BankReport**.

Governing principle — "ONE TRUTH": build from first principles, reflect the real physical and economic world, and use ****no hardcoded address-specific logic**** (general lookup tables and defaults are fine — a per-address special case is not). One feasibility solve drives the placement diagram, the economics and the report alike — the diagram never disagrees with the numbers. Every example is used to find a *general* improvement.

2. The analysis pipeline

```
address (DAR husnummer id)
  → SiteProfile      data fetch + physical/price modelling (backend/app/site.py)
  → screening        legal/spatial feasibility rules (ruleset.py + geo.assess)
  → HiGHS MILP       co-optimize component sizes AND 8760-h dispatch (engine/optimizer.py)
  → outputs          sizes, 20-yr NPV / payback / IRR, self-consumption, CO2, diagram, BankReport
```

Everything downstream of `SiteProfile` is deterministic given the inputs; the same solve result is serialised to `/api/feasibility` and rendered identically in the UI and the PDF report.

3. Data sources at a glance

All sources are free/open and commercial-use-OK. The **only** credential in the whole tool is one free **Datafordeler API key** (Datafordeler Administration → API-key for "frie data"); it is **required at startup** (the service refuses to boot without it) because Datafordeler is the sole address/parcel/ building/roof source since the legacy DAWA backend was retired. Everything else is keyless.

Layer	Source (operator)	Endpoint	Auth	Role
Address search / lookup	Adressevælger / DAR (Klimadatastyrelsen)	<code>adressevaelger.dk/husnumre</code>	keyless token	Address → access point (EPSG:25832); id == DAR husnummer == old DAWA id
Location → nearest address	DAR via GraphQL (Klimadatastyrelsen; via Datafordeler)	<code>graphql.datafordeler.dk/DAR/v3</code>	apiKey	"Use my location" and venue names: a point → the nearest current address (a geometric search on the address points)
Place names	Danske Stednavne (Klimadatastyrelsen; via Datafordeler)	<code>wfs.datafordeler.dk/Stednavn/...</code>	apiKey	Venue and attraction names (e.g. a sports hall) → their location
Cadastral parcel	Matriklen2 WFS (Geodatastyrelsen)	<code>wfs.datafordeler.dk/MATRIKLEN2/...</code>	apiKey	Parcel by point-in-polygon (honours interior rings); area → ground-PV cap

Layer	Source (operator)	Endpoint	Auth	Role
Building footprints	GeoDanmark entity-WFS (GeoDanmark-partnerskabet)	wfs.datafordeler.dk/GEODKV/GEODKV_WFS/...	apiKey	bygning_current footprints + BBR UUID; the on-parcel building set
Building attributes	BBR via GraphQL (kommunerne / Bolig- og Planstyrelsen; via Datafordeler)	graphql.datafordeler.dk/BBR/v3	apiKey	Use code, heated area, build year, heating medium, roof material; existing PV/solar-thermal
Roof geometry	Danmarks Højdemodel — DHM/Overflade DSM (Klimadatastyrelsen)	wcs.datafordeler.dk/DHMnedboer/dhm_wcs/...	apiKey	Per-building roof form, ridge bearing and tilt estimated from the classified-LiDAR DSM
Solar + weather	PVGIS v5.3 (EU JRC)	re.jrc.ec.europa.eu/api/v5_3/seriescalc	keyless	Hourly PV per kWp, in-plane irradiance, 2 m temperature, 10 m wind (configured data year)
Electricity prices	Energi Data Service — Elspotprices + DayAheadPrices (Energinet)	api.energidataser vice.dk	keyless	Day-ahead spot DK1/DK2: the last 12 complete months (15-min prices averaged per hour) mapped onto the weather year's hours
Grid tariffs / tax	EDS DatahubPricelist (Energinet)	api.energidataser vice.dk	keyless	DSO Nettarif C + Energinet transmission/system + elafgift
Grid CO2 intensity	EDS CO2Emis (Energinet)	api.energidataser vice.dk	keyless	Hourly real emission of a consumed kWh (for the reported CO2 estimate)
System residual load	EDS ProductionConsumptionSettlement	api.energidataser vice.dk	keyless	Residual (load – wind – solar) for the systemvenlighet metric
DSO resolution	EDS ConnectionPointsInGrid	api.energidataser vice.dk	keyless	Nearest connection point → net company → which DSO tariff
Wind resource	Global Wind Atlas (DTU)	globalwindatlas.info/api/gwa/custom/Lib	keyless (referer)	Mean wind at hub height; bias-corrects the PVGIS wind shape
Live temperature	DMI Open Data metObs	opendataapi.dmi.dk/v2/metObs	keyless	Live local reading for the UI only (not used in calculation)
Financing rate	Configured realkredit reference + margin (live StatBank lookup planned)	configured default	n/a	Realkredit reference yield → NPV discount rate
Zoning & heat plan	Plandata WFS (Plan- og Landdistriktsstyrelsen)	geoserver.plandata.dk/geoserver/wfs	keyless	Byzone/landzone/sommerhus; fjernvarme/varmeplan; tilslutningspligt- + elvarmeforbud-områder; wind lokalplan
Energy label (EPC)	EMOData (Energiestyrelsen)	emoweb.dk/EMOData/emodata.svc	HTTP Basic (server-side)	Label class + the label's OWN calculated heat demand, heated area, energy frame and costed improvement proposals — anchors the heat-demand scale when no user figure is given

Layer	Source (operator)	Endpoint	Auth	Role
DSO per address	Find Netselskab (Green Power Denmark)	<code>api.elnet.greenpowerdenmark.dk/api/supplierlookup</code>	keyless	Authoritative net company + netområde for the address (falls back to nearest connection point, then kommune/region)
District-heating price	Forsyningstilsynets fjernvarmeprisstatistik	semi-annual CSV, bundled (backend/app/data/fjernvarmepriser.csv)	n/a (static)	The local plant's ACTUAL consumer price (standardhus/-lejlighed basis) replaces the national default when the address sits in its area
Soil / ground conditions	GEUS jordartskort 1:200.000 + Miljøstyrelsen grukos (BNBO/OSD)	<code>data.geus.dk/geusmap/ows · wfs2-miljoegis.mim.dk/grukos/ows</code>	keyless	Surface-geology class at the point → specific heat extraction (VDI 4640) for the ground-source heat-pump variant; BNBO/OSD sharpen the permit caveat
Protected areas	kort.vd.dk "Grunddata" ArcGIS (Vejdirektoratet)	<code>kort.vd.dk/server/rest/services/Grunddata</code>	keyless	Klitfredning, strandbeskyttelse, §3-natur, fredede områder, Natura 2000, fredede bygninger , building lines (point identify → the rule gate)
Protection POLYGONS	Matriklen temaer (Geodatastyrelsen) + Danmarks Miljøportal Arealdata	<code>wfs.datafordeler.dk/MATRIKLEN2/... (apiKey) · arealeditering-dist-geo.miljoportal.dk/geoserver/wfs</code>	apiKey / keyless	Strandbeskyttelse, klitfredning, fredskov , §3-natur, fredninger, Natura 2000 as GEOMETRY — clipped out of the plantable field (only the protected corner is lost, not the whole mark) and drawn hatched on the placement
Crop parcels	Landbrugsstyrelsen IMK/Marker WFS	<code>geodata.fvm.dk/geoserver/ows</code>	keyless	Is the field APPLIED-FOR farmland this year, and which crop — corroborates the NIR barmark evidence (crop facts only; applicant identifiers are deliberately not read)
CO ₂ declaration	EDS DeclarationGridEmission (Energinet)	<code>api.energidataser.vice.dk</code>	keyless	Annual declaration factors (direct + upstream origin, 125 % method) for the report's scope 2 context — the savings math keeps using the HOURLY real emission (CO ₂ E _{mis})
Municipal PV adoption	EDS CapacityPerMunicipality (Energinet)	<code>api.energidataser.vice.dk</code>	keyless	Number of grid-connected PV plants + MW in the address municipality (context, monthly)
Housing-market context	Danmarks Statistik EJEN77	<code>api.statbank.dk</code>	keyless	Latest quarter's realised single-family sales (average price + count) per DST region — regional context, never a valuation of the property

Layer	Source (operator)	Endpoint	Auth	Role
Oblique aerials	Skråfoto viewer (Klimadatastyrelsen)	skraafoto.datafor syningen.dk	keyless deeplink	One-click oblique views of the roof from four directions (verification aid)

Weather year and price basis. Hourly weather (PVGIS: PV, temperature, wind) uses the **configured weather year** (`EA_DEFAULT_YEAR` , currently **2023**; `build_site` accepts a per-request override). Electricity prices use **the market as it is now**: the **last 12 complete months** of day-ahead prices for the address's price area (DK1/DK2; at the time of writing October 2025 to September 2026), placed onto the weather year's hours by a rank-preserving mapping (below). The window is pinned at a release and rolled deliberately (admin setting `prices.spot_window_end` , e.g. quarterly), so results are stable and a report re-run a month later gives the same numbers; it can never point at months without data. Every answer records the window it used (`site.spotBasis`), and a cached answer is never served across windows: the window is resolved once per request and carried into both the site build and the cache key. An admin policy leaf (`prices.spot_basis`) switches back to the weather year's own prices.

Why 2023 weather. It is the newest calendar year PVGIS (SARAH3 satellite radiation) serves; PVGIS lags roughly two years. The weather year must be one physical year, so PV, temperature, wind, heat demand and load stay aligned hour for hour (see *Time base*).

Why recent prices, and how they meet 2023 weather. A pre-feasibility study should price the system in today's market: a "frozen system" stance that holds the current market rather than forecasting it. Since 2023 the Danish day-ahead market has moved: the level is higher, evening peaks are much higher, and the market switched to 15-minute settlement on 1 October 2025. Placing raw recent prices on 2023 weather would destroy the hourly correlation (a sunny 2023 hour would get an arbitrary 2026 price, and solar's real discount in sunny hours would vanish). The prices are therefore **quantile-mapped within each (calendar month, hour of day) bucket**: in each of the 288 buckets, the weather year's hours are ranked by their own 2023 price and given the window's prices for the same bucket at the same rank. Every hour keeps its weather-consistent position (the sunniest, windiest hours stay the cheapest), while the price level and its distribution come from the window. Measured on the current window:

	DK1 2023	DK1 window	DK2 2023	DK2 window
Mean spot (kr/kWh)	0.647	0.756	0.605	0.771
Mean daily spread, 4 dearest minus 4 cheapest hours (kr/kWh)	0.566	0.800	0.591	0.834
Highest / lowest hour (kr/kWh)	3.91 / -3.28	5.52 / -0.23	3.91 / -0.45	5.35 / -0.11
Negative hours	281	230	231	109

The summer months carry most of the change: the window's mean daily spread in May to September is 1.0 to 1.26 kr/kWh against about 0.6 in 2023.

Hourly resolution vs 15-minute prices. Since 1 October 2025 the day-ahead market settles in quarter hours; the model works in hours on the mean of the four quarter-hour prices. Measured on the window, resolving the quarter hours would raise the mean 4-hour battery spread by about 4 % (DK1 0.800 to 0.834 kr/kWh); the typical price range inside an hour is about 0.16 kr/kWh. Hourly resolution is retained: the refinement is worth a few percent of battery value and would quadruple the size of the optimisation.

What holding today's market means. The window's level and spread are held flat in real terms over the 20-year horizon (§8). The result is a point estimate for one weather year in today's price regime, not a probability distribution. Today's regime is dearer and markedly more volatile than 2023 (DK1 mean +17 %, daily spread +41 %), which raises the value of self-consumption, batteries and heat shifting compared with a 2023 price basis. Spreads are the most volatile part of the market and the most exposed to erosion as storage is built out; this is one reason a home battery is modelled as serving the building, not trading with the grid (§8). The risk analysis re-prices

the chosen design across a band of price levels and spreads centred on the same window (§8, *Price risk*), so the headline result is the central case of that band.

Time base. Every hourly series is placed on **one canonical Danish wall-clock grid** (8760 h), and every value is the **average over that hour** (from h:00 to h+1:00), as electricity prices, tariffs and consumption are. PVGIS gives **instantaneous** values at ten past each hour in **UTC**, so PV/temperature/wind are first turned into hourly averages and then converted to **Europe/Copenhagen** (DST-correct); the sun path used for shading is taken in the middle of each hour. The EDS series (spot, residual, CO2) are keyed on **HourDK** and reindexed onto the same grid (the fall-back duplicate hour is collapsed, the spring-forward gap filled). This keeps PV, load, price, residual and CO2 aligned **hour-for-hour** - so self-consumption value, price-timing, the hourly CO2 credit and the system-venliged correlation (§9) are computed for the same hour (until October 2026 PV still ran about 20 minutes late against prices).

4. Address, parcel & buildings

Datafordeler is the **single source of truth** for geometry (the DAWA backend was removed after a live parity check; DAWA itself closed on 1 Oct 2026). The chain per address: (1) the DAR husnummer id resolves to an access point in EPSG:25832 (Adressevælger); (2) the Matriklen2 WFS returns the cadastral parcel whose polygon **contains** the access point, honouring interior rings (an enclave punched out of an enclosing field is correctly excluded) — selected by geometry, never by an area heuristic; (3) GeoDanmark building footprints are fetched **once** in EPSG:25832; a building is "on-parcel" when its centroid lies inside the parcel ring, and the same 25832 fetch is reprojected to WGS84 for the map, so the **map's on-parcel set is identical to the set the economics use**. Building attributes (use code, heated area, build year, heating medium, roof material, registered existing PV/solar-thermal) come from **BBR via GraphQL** at the current registration time. BBR carries roof *material* but **no roof shape** — that comes from DHM (§5).

5. Roof geometry & PV placement

The orientation of a roof drives its solar yield, so each on-parcel building's roof is characterised **per building** from the best available source:

- **Primary — Danmarks Højdemodel (DHM/Overflade DSM).** The national digital surface model, derived from classified LiDAR, includes building roofs. For each building we fetch the DSM tile over its footprint (WCS, EPSG:25832, GeoTIFF), mask it to the footprint and erode one cell, then classify from the masked roof heights: relief below ~1.2 m → **flat**; otherwise the top-height cells' PCA linearity ≥ 2.5 → **gable/sadeltag** (with the measured ridge bearing), else **hip**. Tilt is estimated as $\text{atan}(\text{relief} / \text{cross-ridge-half-span})$, clamped to 12–55°. These (FLAT_RELIEF 1.2 m, GABLE_LINEARITY 2.5, the tilt clamp) are **tuned heuristics on the height-cell distribution**: the values are *measured* from the real LiDAR surface, but the flat/gable/hip label is a classification, not a survey — it is a strong estimate, not a certainty, and on near-square or genuinely hipped roofs it resolves to hip or falls back. Lookups are bounded — only buildings $\geq 25 \text{ m}^2$, and at most the **16 largest** on the parcel — so a garden-colony of sheds never fans out into hundreds of requests; smaller buildings use the footprint fallback below. A network/parse/too-few-cells failure is treated as **retryable** (it falls back this request and retries later, never pinned), while a real result (including a measured flat roof) is cached.

- **Fallback — footprint heuristic.** When DHM is unavailable (or for a building below the size cut), the roof is inferred from the 2-D footprint, defaulting a pitched roof to a **gable (sadeltag) along the footprint's long axis**. (The earlier "near-square $\Rightarrow$ hip / four cardinal wedges" default was unrealistic and confusing; a hip is now only drawn when DHM actually classifies one.)

The resulting roof planes feed two consumers from **one descriptor** (so they can never disagree): the optimiser's per-orientation PV faces (each priced with its **own** PVGIS yield, so a south slope is full value while an east/west or partly-north slope is correctly de-rated), and the **placement diagram**. The diagram is **geometry truth** — building + ridge + slopes are drawn whenever the footprint exists, *even when roof PV is legally forbidden* (e.g. a listed building), in which case the slopes render unshaded with the reason shown. Shading is **solve truth**: a plane is

shaded only if the optimiser actually placed PV on its orientation. When DHM was used, the report says the orientation is read from the height model.

The usable roof is a **shared resource**: new roof PV and new solar-thermal compete for the same square metres — $\Sigma(\text{face kwp} \div \text{kwp-per-m}^2) + \text{solar-thermal m}^2 \leq \text{usable roof m}^2$ — so a roof cannot host both at full size. Existing roof PV / solar-thermal **registered in BBR** is detected and reserves its share of the usable roof (existing solar-thermal area, when not in BBR, is estimated from its kW_{th} rating at ~0.7 kW_{th}/m²), and existing PV is netted in the economics — so a recommendation only ever covers the *free remaining* roof and never double-counts what is already installed. (BBR registration is owner-reported, so absence is not proof of "no system".) A flat roof's PV tilt (25°) is a south-turned racking *assumption*, not a measured slope.

6. Screening / feasibility rules

Before optimising, each component is screened against legal and spatial constraints (`backend/app/ruleset.py` over a context assembled by `geo.assess`). Rules are an ordered list per component; **first match wins**; no match → ALLOWED. Every gate carries a regulatory reference or a configurable threshold, nothing is fabricated, and **missing data degrades to CONDITIONAL, never FORBIDDEN**. ALLOWED and CONDITIONAL are both buildable; only FORBIDDEN removes the option.

- **Protected areas (forbid solar/wind)**: klitfredning (NBL §8), strandbeskyttelse (§15), §3-beskyttet

natur, fredede områder, Natura 2000 — from the kort.vd.dk Grunddata identify layers. In addition the protection POLYGONS (incl. fredskov) are clipped GEOMETRICALLY out of the plantable field, so a large parcel whose corner is protected keeps the rest of its mark — the point gate decides legality per component, the polygons refine the AREA. Missing polygon data degrades to the point-gate behaviour.

- **Listed buildings**: a *fredet bygning* (FBB `fredet=1`) forbids roof PV (Bygningfredningsloven §10 —

visible roof panels need Slots-/Kulturstyrelsen dispensation); a *bevaringsværdig* building (value 1–4) is a CONDITIONAL caveat, not a block. (*Example: Vesterbrogade 148, "Sorte Hest", is genuinely fredet — roof PV is correctly suppressed, but the building is still drawn with the reason shown.*)

- **Building-protection lines (require kommune dispensation)**: skov-, sø-, å-, kirkebyggelinje (NBL

§16/17/19); inside a fortidsmindebeskyttelseslinje (NBL §18) even visible roof panels need dispensation.

- **Zone**: ground-mount PV and onsite wind require landzone (Planloven); in byzone/sommerhusområde roof PV is used instead.

- **Heat**. Two district cases are distinguished: a home in a fjernvarme område but currently on

individual heating gets a new heat pump as CONDITIONAL (connection/retention obligations may apply; a municipal varmeplan for individual supply lifts it to ALLOWED); a home **already on district heating** is *not* offered a new heat pump (its capacity is fixed to 0 in the optimiser) — it is instead offered PV / battery / (and, since district is hydronic) solar-thermal + heat store that cut net purchases. An existing heat pump is likewise retained (no second pump recommended). Solar-thermal and a thermal store require a hydronic system and are suppressed in district-heating areas.

7. Demand & physical modelling

Hourly inputs for the optimiser are pre-computed in `backend/app/profiles.py` and `site.py` :

- **Heat demand (user-anchored where consumption is given)**. For electrically-heated homes (heat pump /

resistance — the dominant case) the *authoritative* input is the household's **entered annual heating electricity**, back-solved through the heating system's hourly COP (or resistance efficiency) into an hourly thermal-demand series. The shape is a temperature-driven degree-day profile that is also **occupancy-weighted** (deep-winter empty-house hours are damped). Only when no consumption is entered — and for **fuel-heated** homes (gas / district / oil / wood) — does the demand fall back to the BBR heated area × an era-specific heat figure (with a ×0.40 reduction for summer houses). So the headline heating figure is user-anchored where consumption is supplied, not

a pure m²-based estimate.

- **Hot tap water follows the people, not the building.** Its annual amount is the dwellings × an assumed occupancy (2.5 persons in a single-family house, 1.8 per flat in a multi-family project) × ~765 kWh per person (about 40 litres of 55 °C water per person per day), and never more than 18 % of the home's annual heat. It is drawn evenly over the year; the rest of the heat demand is space heating on the degree-day shape. Where the heat is backed out of the entered heating electricity, the split is solved together with it, so the entered electricity is still reproduced exactly.
- **Heat-pump COP[t]** depends on the home's heat-distribution system: a hydronic (water-loop) home uses the **air-water** curve (weather-compensated radiator sink); an electric-panel / air-to-air home, with no water loop, can only add an **air-air** split, modelled with a lower fan-coil curve floored at ~1.8 in deep cold. An existing pump keeps its own curve.
- **Heat pumps as installed (first principles).** A heat pump is sized and priced by its **thermal output** (kW of heat at the A2/W35 rating point); an air-source pump delivers less in frost (~2 % per K below +2 °C, never below 60 %), and every water-based heat pump - new or existing - has its **built-in backup elpatron** (~6 kW) for the coldest hours. **Hot tap water** is made through the pump's own hot-water cylinder (~200 L) at ~52 °C, i.e. at a lower COP than floor/radiator heat, with the cylinder's standing loss; the cylinder serves the shower peaks, so the pump never has to; it is reheated through its coil (~6 kW, about 1.5 hours for a full cylinder). An existing heat pump is assumed sized to the house: its output covers the household's own heat and hot water in the coldest hour, and its backup elpatron covers anything beyond. An air-to-air split makes no hot water (an electric water heater does). A heat pump does not charge the larger thermal store - the store's immersion heater does - and the store (35-75 °C) feeds the space-heating circuit, not the hot tap water.
- **Electricity load** — a household base profile scaled to the entered/estimated annual consumption.
- **Process / ventilation load (productive buildings)** — for non-dwelling productive buildings the model adds an estimated electricity load: *stalde* ~30 kWh/m²/yr as a flat year-round ventilation baseload, *erhverv/værksted* ~60 kWh/m²/yr on a weekday-daytime profile. Footprint m² (BBR) × an admin-tunable kWh/m²/yr intensity (`ruleset.PROCESS`); a rough estimate (no per-building meter), netted out of the household residual when a single meter total is entered, and divided across dwellings for a multi-block.
- **EV (opt-in).** No electric vehicle is included unless the user adds one (`vehicle_kwh` > 0) — the default assumes no car. When added: annual km → daily charge energy, a weekday-commute home-availability window (plugged in except weekdays ~07–16), and an away-charging share (a scalar fraction charged off-site). A dumb evening-arrival (~17:00) charge profile is the uncontrolled baseline the optimised smart-charging is compared against (all parameters, not decisions).
- **Summer houses (fritidsejendom).** Space heat, household electricity and any EV home-charging are redistributed onto a seasonal occupancy weight (mid-summer, weekends, holiday breaks; minimal deep-winter presence), re-normalised so only *when* energy is used changes, not the annual total — plus the ×0.40 area-heat reduction noted above.
- **Multi-dwelling buildings (etageejendom)** are modelled as a *foreningsprojekt*: the whole building's consumption and all components are sized at building level (not per apartment), using the real apartment count from BBR (Enheder) when available, else an estimate from heated area; economics reported at the building / owners-association level.
- **Weather & solar.** PVGIS supplies hourly PV-per-kWp, 2 m temperature, 10 m wind and in-plane irradiance for the configured year. Solar-thermal useful heat is computed from the in-plane irradiance G(i) via the **EN-12975 flat-plate efficiency curve** ($\eta = \eta_0 - a_1 \cdot \Delta T / G - a_2 \cdot \Delta T^2 / G$; typical $\eta_0 \approx 0.78$, $a_1 \approx 3.5$, $a_2 \approx 0.018$, mean fluid ~45 °C, no storage-temperature feedback). Wind: the PVGIS 10 m wind is extrapolated to a ~50 m effective height via a power law ($\alpha \approx 0.2$), passed through a generic cubic small-turbine power curve (cut-in 3.5 / rated 11 / cut-out 18

m/s) with a flat **0.85 availability derate** standing in for the large uncertainty of an emerging product; the wind level is then bias-corrected so its 50 m mean matches the Global Wind Atlas (scale clipped 0.6–1.8).

8. Prices & economics

Prices are built to the real Danish, incl-VAT, time-differentiated reality (`profiles.py` + `tariff.py`):

- **Import price[t]** = (spot + DSO Nettarif C + Energinet transmission + Energinet system + elafgift +

supplier margin ≈ 0.03 kr/kWh) $\times$ **1.25 (moms)**. The DSO is resolved from the nearest EDS connection point; if that returns no usable match, a curated, editable region/kommune→net-company table is used (a general default, **not** a per-address special case). **Elafgift** follows the legislated ladder (lov nr. 1775 af 29/12/2025, verified against Lovtidende): 0.8 øre/kWh 2026–27, 60.9 øre (2015-level) 2028–29 and 59.9 øre from 2030, indexed — modelled in fixed real terms as 0.727/0.715 kr/kWh (the 2026-price equivalents) and NPV-blended over the horizon (~ 0.63 kr/kWh at 20 yr). **El-heated homes** (BBR-registered electric/heat-pump heating, incl. el-heated summer houses) instead face the **elvarmesats** (ELAL §6 stk. 1, 1. pkt.): 0.8 øre/kWh on consumption above 4,000 kWh/yr — also after 2028 — so their marginal electricity is modelled at that rate (the first 4,000 kWh/yr at the ordinary rate is identical with and without the plant and cancels in the savings). Fossil→heat-pump conversions are conservatively NOT credited the elvarmesats (registration follows conversion; noted in the report). **Egenproducentbidrag** (from 1/1-2026, the Green Power Denmark industry method): a fixed annual DSO charge per kW of installed production capacity above the 30 kW exemption for low-voltage prosumers (default 100 kr/kW/yr ex VAT, utility-specific and editable) is charged post-solve on the new plant's capacity beyond the exemption; pure production-connected plants instead carry the feed-in tariff already in the export price.

- **Export price[t]** $\approx$ spot minus a small feed-in/balance tariff, **no VAT** (it is income); it can go negative when spot is negative.

- **A home battery serves the building.** It charges from on-site generation and from the grid (moving purchases into cheap hours) and discharges only into the building's own consumption: hour by hour, export never exceeds on-site generation. Trading grid electricity back to the grid would pay tariffs, taxes and VAT on every kWh bought and earn only spot on every kWh sold; where it still looked profitable (an electrically heated home on the reduced elvarme tax, with today's spread held for 20 years), it rested on a tax rate meant for heating and on the most erosion-prone part of the market. Measured before the rule, a nine-dwelling row house was otherwise recommended a 489 kWh battery that drew 86 % of its charge from the grid and exported 87 % of its discharge. Commercial export models (solar parks) keep their own market regime. An admin policy leaf (`battery_grid_export`) allows trading.

- **The inverter is part of the decision.** Its AC rating is chosen by the optimisation, not sized afterwards: it must carry the battery's rated power and, every hour, the solar output plus battery discharge passing through it (the optimisation may let a few peak hours clip when a smaller inverter pays), never below the panel power divided by the product's DC/AC limit (1.5). It is priced at its market price per kW plus a base price, in the optimisation and in the NPV used to rank designs, so the inverter that is shown is the one that is priced and ranked. A hybrid inverter sized for the solar panels also carries a battery; only a battery without new panels (or one much larger than them) pays for its own inverter. Components that share an asset like the inverter are also evaluated together when the tool tests whether the design is beaten by one of its own sub-designs (see post-solve corrections below).

- **Price risk.** The risk analysis re-solves the dispatch of the FIXED design across ~ 18 price scenarios (triangular draws of the mean level and the daily spread, deterministic seed). The band is centred on the analysis' own price basis (the window, so the headline is the central case) and is never narrower than ± 20 % in level, or the largest year-to-year move in the recent full years (capped at 60 %); the spread varies by half as much. A design is flagged price-sensitive when more than 15 % of draws lose money, the 10-90 % band straddles zero, or the 90th percentile exceeds 2.5 times the 10th.

- **Counterfactual heat prices** ("do nothing", flat, incl-VAT, real terms, admin-adjustable defaults —

not address lookups): gas/oil/biomass boiler ≈ 0.95 kr/kWh fuel ($\eta \approx 0.92 \rightarrow \approx 1.03$ kr/kWh delivered heat); district heat ≈ 0.75 kr/kWh variable (excl. standing charge); electric resistance at the hourly import price ($\eta \approx 0.99$); an existing heat pump at import price $\div$ COP[t].

- **CO2 — reported, not priced.** Avoided CO2 is *estimated* by valuing each imported/avoided/exported kWh

at the hour's real grid-AVERAGE emission intensity (EDS CO2Emis; a flat ~ 0.057 kg/kWh, declining toward ~ 0.04 , is the fallback when the hourly series is unavailable) and fuel heat at gas 0.205 / district 0.06 kg/kWh, with the **avoided** figure floored at zero (baseline/optimised emissions stay signed, so existing-PV export credit is not lost). CO2 carries **no price in the cost objective**. Convention note: a *marginal*-displacement intensity (~ 0.15 kg/kWh) would give a materially higher — roughly double — avoided figure; we deliberately report the lower grid-average number to match the standard framing.

- **Discounting.** Because energy prices are held flat in real terms, cash flows are discounted at the

real rate via Fisher: $\text{real} = (1 + \text{nominal}) / (1 + \text{inflation}) - 1$, where nominal = a *configured* real credit reference ($\sim 4\%$) + margin (a live StatBank lookup is a planned refinement). Annualisation uses the capital recovery factor $\text{CRF} = r(1+r)^n / ((1+r)^n - 1)$ over a 20-year horizon, with mid-horizon replacements (heat pump/wind once; battery by cycle-life) and straight-line salvage.

- **CAPEX** is real, incl-VAT, per-technology **fixed install floor + marginal**. The MILP optimises on the

marginal only; the fixed cost and an **NPV floor** (build nothing if $\text{NPV} < 0$) are applied **post-solve**. Heat-pump cost is not uniform: a hydronic home is priced for an air-water pump (higher marginal + a larger install floor for the buffer tank/plumbing), a non-hydronic home for the far cheaper air-air split — so an electric-panel home is never charged air-water prices for a pump it cannot fit.

- **Competitive offer.** A configurable **market discount (default 15 %)** is a *post-solve* offer: the MILP

sizes on full market prices, and only the reported price/payback/NPV carry the discount. It applies to the technologies still priced generically (heat pump, thermal store, wind, solar thermal, scaffolding, and the battery outside the product line's envelope), not to a Systempakke PV plant or battery (below), whose prices are real catalog prices.

- **Systempakker: PV priced from real products (2026-09).** For every plant within the product line's

envelope (a single dwelling whose largest possible array can be carried by at most two of the line's inverters; MW sites and owners' associations keep the generic pricing), the PV plant is priced from a supplier catalog of real products: panel (LONGi Hi-MO X10 475 W, $1\,800 \times 1\,134$ mm), hybrid inverter, smart meter, isolators, DC cable and mounting parts per roof type (BBR roof code $\rightarrow$ a K2 or JUAL recipe; thatch is excluded from roof PV; asbestos, glass, green and plastic roofs carry a caveat), plus labour hours $\times$ an hourly rate for design, installation, test and monitoring. The MILP optimises on a **linearised** catalog price per roof face (panel + mounting + strings + labour per kWp, plus the inverter price slope per kWp DC; the fixed part is charged post-solve). The chosen design is then **realised** in whole panels per face: the inverter is the cheapest one whose datasheet PV input covers the DC array (DC oversizing up to 150–200 % per series) with one MPPT per orientation and strings inside the voltage window at $-15/70$ °C cell temperature, and a pinned re-dispatch **clips the hourly AC output at that inverter's rating** (clipping losses are priced, not ignored). When the realised design would need more than one inverter, the design with each array removed is evaluated and the best *realised* NPV wins; headline, ranking and the NPV floor all use the realised bill of materials. The linearised price tracks the realised price within $\pm 3\%$ for single-inverter designs.

- **Ejerform (investor-type) — VAT/duty/tax differentiation.** The analysis is computed for one of seven

ownership forms (privatperson · virksomhed · kommune/region · almen boligforening · andelsboligforening · industrivirksomhed · stat), auto-derived from the property (EJF ejerforholdskode $\rightarrow$ BBR use $\rightarrow$ project archetype) and user- switchable under Forudsætninger. **One truth, two layers:** the ONE energy balance is unchanged; the legal/tax layer changes per form. For VAT-reclaiming/refunded forms (virksomhed, industri: momsloven §37; kommune/region: momsrefusionsordningen; stat: statens momsordning) CAPEX and electricity are priced **ex-VAT**, and momsregistrerede forms get **elafgift godtgjort to the EU minimum** (elafgiftsloven §11) — these effective

prices go **into the MILP**, so the optimal plant genuinely re-sizes per form (self-consumption value drops, export orientation rises). Post-solve, all seven forms' economics are re-priced on the **same dispatch** (comparison overlay, clearly labelled), and a year-by-year **after-tax cash flow** is built per form: corporate tax 22 % on (savings – saldo/\$5C depreciation), municipal tax on export profit only (SEL §1); housing organisations (almen: SEL §3's electricity carve-out; andelsboligforening: SEL §1(1) no. 6) are likewise taxed 22 % on settled net sales while direct self-consumption stays tax-free, LL §8P (skematisk) for private sellers, udtagningsmoms (ML §5) as an editable share — with reinvestment/salvage mirroring the NPV convention exactly. Every rule is a one-truth store leaf carrying its **legal basis and a conservative confidence grade**, surfaced verbatim in the report's BILAG E. The privatperson default is byte-identical to the pre-feature engine.

- **PV-yield realism.** Every PVGIS capacity factor is de-rated $\times 0.906$ (field losses + IEC degradation),

so sizing and the reported yield reflect the 20-year horizon, not year 1. (The degradation mean is energy-weighted over the 20-year *evaluation* horizon while PV CAPEX is amortised over the panel's 30-year *asset* life with the remaining years credited as salvage at year 20 — matched energy- and capital-side accounting, not conflicting horizons.)

- **Battery realism (home LFP, first principles).** Round-trip efficiency is the **AC-AC system** figure

≈ 0.88 (the hybrid inverter's two conversions + BMS parasitics, not the optimistic ~ 0.90 DC value); usable energy ≈ 0.83 of nameplate (a BMS bottom buffer $\times$ lifetime-average state-of-health over a 15-yr life fading $\sim 100 \rightarrow 80$ %), so capex is paid on nameplate but only $\sim 0.83 \cdot E$ is bankable. **One wear model** in the optimisation and the economics: the battery is replaced after 15 years OR 6000 full cycles, whichever comes first. Cycling within the calendar budget ($6000 / 15 = 400$ full cycles a year of the usable capacity) is paid by the replacement already in the capital; only throughput beyond it costs ~ 0.35 kr/kWh discharged. Power is 0.5 C (charge and discharge $\leq$ half the nameplate per hour), the same figure the inverter and the result show.

- **Real battery products (2026-10).** Within the Systempakke envelope the battery is a real product, the

Solplanet Ai-HB G2 Pro on the hybrid inverter's battery input, in both the analysis and the price. Its datasheet sets the physics: 1 C (50 A at the module voltage), usable energy = 95 % depth of discharge $\times$ the same lifetime-average state of health (0,90), round trip 0,95 (battery) $\times$ 0,972² (the hybrid, each way) $\approx 0,90$ AC-AC, and 8000 cycles at 90 % depth of discharge (7200 full cycles) in the wear model above. It comes in towers of 3-8 modules of 2,56 kWh (7,68-20,48 kWh); towers in parallel must have the same number of modules, and more towers than the inverter has battery inputs need a combiner box. The smallest real battery is therefore 7,68 kWh for every model. The optimisation sizes the battery smoothly on the module price per kWh (the controller per tower is a fixed cost), and the final design is realised as a real configuration: the nearest one, or the smallest that meets a requirement (backup reserve, a package minimum, the user's choice), and for a free battery the neighbouring configurations are compared on the realised economics. The battery's power is what the chosen inverter's battery port delivers at the tower voltage (current $\times$ voltage, capped by the inverter's battery power) - a 7,68 kWh tower on a 5 kW hybrid with a 30 A port gives 4,6 kW, and the result says so. A battery without new solar panels is bought as a package too: the cheapest hybrid that can carry the tower, a meter and the battery, with larger inverters chosen only when they pay. Prices: the supplier's list price for consumers, installer accounts and Pro customer projects (the public result, the installer's console and the customer version of every report are bit-identical); cost price only for the owner's own project (a Pro account with cost-price rights, never an installer account); labour at the hourly rate (3 h per tower + 0,25 h per module by default).

- **A second battery family (2026-10).** Batteries are now sold well below the main supplier's list price, so

the analysis also knows the Dyness Tower (T7-T17: 2-5 modules of 3,552 kWh in one tower, 7,10-17,76 kWh), priced from a European distributor's public price list (the distributor is named in the budget). The inverter maker approves it only on the smaller hybrids (Solplanet H-T2/T3, up to 12 kW); the larger TH series takes only Solplanet's own battery. Its datasheet sets its own physics: 0,6 C (the power the maker states when the battery talks to the inverter), usable 95 % $\times$ the same lifetime-average state of health, and 6000 cycles counted at 80 % depth of discharge (4800 full cycles) - shorter than the Solplanet battery, so the wear model above binds sooner. The optimisation itself sizes the system as before; when the design is turned into real products, every battery family the chosen inverter can carry is tried at the nearest size - and a design without a battery is tried with the

cheaper family's smallest tower - and the better realised economics decides, after which the battery size is adjusted on the realised economics. A design that needs the larger inverter therefore always gets the Solplanet battery, and the smallest real battery is 7,10 kWh where the small hybrid suffices. The Dyness tower ships with a 2 m cable to the inverter, so the report says it must stand next to the inverter.

- **Generic batteries in two tiers (2026-10).** Outside the product catalog (owners' associations, businesses, field and large-roof projects) a battery is priced from market prices in two tiers: one price per kWh for both, set at the cheapest real product the catalog prices (about 205 EUR/kWh before VAT for the battery itself, without the inverter), plus a fixed part - a residential battery pays it per unit of up to 30 kWh (one hybrid inverter each), a commercial battery cabinet from 50 kWh pays one project cost. The cheaper of the two for the chosen size is used: a 10 kWh battery costs about 29.000 kr incl. VAT as an offer (the same as the real product a single home would get), and a 500 kWh commercial battery about 260 EUR/kWh before VAT including its power conversion. Before, the generic battery was priced far from the real products in both directions.

- **Heat pump sizing follows DS 469 (2026-10).** When a fossil boiler is replaced, the heat pump must cover the whole heat demand down to the bivalent temperature of -7 °C (the Danish standard's limit), with the electric backup only below that. The demand at -7 °C is read from the house's own heat profile, so the minimum pump size no longer depends on how cold the weather year happened to be. The optimisation may still choose a larger pump when it pays.

- **An existing solar array is not new (2026-10).** Its production is the yield of the roof face it sits on, reduced for its age (the same 0,65 %/year degradation the new panels get, counted from the year BBR says it was installed), and the household keeps paying for its own inverter: a renewal reserve is part of today's cost as well as of every plan that keeps the array, and disappears from a plan that removes it.

- **Falling battery prices (2026-10).** Today's purchase is priced at today's price, but the battery's replacement in year 15 and its residual value at the end of the horizon follow a real price decline of 3 % per year - a conservative reading of the last decade (battery pack prices fell by 80-90 %). Solar panels and the other components are treated as stable in real terms. The reinvestment shown in the capital schedule is the declined price, and the same rule is used in the NPV and in the year-by-year cash flow.

- **Post-solve corrections.** Because the MILP sees only marginal cost and its size floor is all-or-nothing, a small battery whose arbitrage can't earn back its fixed install can ride along; post-solve, for a battery < 20 kWh the tool re-dispatches with it pinned to 0 and the rest held, and drops it if that lifts the 20-yr NPV. (Large owners-association/commercial batteries amortise their fixed cost and are exempt.) **No shown design is beaten by one of its own sub-designs:** after the solve the tool re-solves the design without each built component in turn (the rest re-optimised, priced exactly like the answer, fixed costs included) and keeps any sub-design with a higher market NPV, repeating until none is better; components that share an asset (solar panels and battery share the inverter) are also tested without the whole group. The NPV floor follows the same rule: a design whose market NPV is negative first falls back to its best positive sub-design and only then to building nothing. Where products are realised as a catalogue bill of materials, the "build nothing" decision is made on the realised economics, the same numbers the user sees.

9. The optimisation model (MILP)

A single-node, two-carrier (electricity + heat), grid-connected, behind-the-meter **capacity-expansion + 8760-h dispatch** model that co-optimises component sizes and operation to **minimise annualised total system cost** (equivalently, maximises NPV vs the baseline). Solver: **HiGHS** via **highspy**, pinned to its **deterministic dual-simplex with a fixed random seed** — HiGHS's default "choose" mode can otherwise fall back to an approximate first-order solver (PDLP/IPM) under some execution contexts (e.g. the uvicorn worker thread) and return a *suboptimal* LP; pinning the simplex makes the optimum unique and **byte-identical across the API, the PDF report and batch runs**, which is what backs the \$10 "one solve, one truth" promise. Design reference: PyPSA single-node sector-coupling.

- **Sizing variables.** Roof PV (per orientation face), ground PV, battery energy & power, heat-pump power, thermal-store capacity and solar-thermal collector area are **semi-continuous** (0 or $\geq$ a real product minimum) — each ≥ 0 ("0 = don't buy it"), capped by \$5–\$7. The engine first solves the continuous **LP relaxation** exactly; in the common case every component already lands buildable and that optimum is used directly, escalating to a true semi-continuous **MILP** (warm-started from a feasible floor) only when a component lands in the (0, product-min) dead zone. **Small wind is currently sized continuously** — its integer-whole-turbine constraint is a Phase-4 item — so a reported wind size is not yet guaranteed to be a buildable whole-turbine product.

- **Dispatch variables (per hour):** grid import/export, battery charge/discharge/SoC, heat-pump electricity → heat ($\times$ COP, within the pump's thermal capacity at the hour's outdoor temperature), the pump's hot-water cylinder (charge at the hot-water COP, draws, state), thermal-store charge/discharge/SoC, an **immersion heater (elpatron, ≤ 11 kW, $\eta \approx 0.99$, with a thermal store and scaled to it at ~ 0.6 kW/kWh)** that can absorb cheap/surplus electricity into the store, the heat pump's **built-in backup elpatron** (~ 6 kW), EV charge/SoC, and used PV/wind/solar-thermal generation ($\leq$ available, free curtailment).

- **Constraints:** hourly electricity and heat balance; generation $\leq$ capacity $\times$ profile; battery and thermal-store SoC with cyclic year boundaries; EV SoC with departure minimums; the shared-roof PV-vs-solar-thermal area cap (\$5); and a realistic **grid-connection limit** (~ 25 kW, scaled by dwelling count for a foreningsprojekt) that caps discretionary import/export — the import ceiling is raised where the must-serve load exceeds it so the model stays feasible, and the **same export cap is applied to the baseline** so it never creates a phantom saving. This prevents a "build a solar farm to export at spot" artefact.

- **Baseline (counterfactual):** the same property with the new components fixed to 0 and heat met by the property's **actual BBR-registered carrier** — a gas/oil/biomass boiler ($\eta \approx 0.92$), electric resistance ($\eta \approx 0.99$), an existing heat pump at its hourly COP, or district heat at its tariff — **not universally a gas boiler. Feasibility value = baseline annual cost – optimised annual cost**, rolled into 20-year NPV, payback and IRR.

- **Solve discipline & honesty.** The full-year solve has **perfect foresight** of weather and prices, so the reported **sizes AND the headline economics (NPV, payback, IRR, annual savings) are an optimistic UPPER BOUND** — a real foresight-free controller will under-perform them, most on battery/EV/thermal-store arbitrage (PV self-consumption least). No de-rating is applied today; a rolling-horizon re-dispatch (or an equivalent ~ 10 – 15 % haircut on storage arbitrage) is a planned realism lever, **not yet implemented** (§12). On MILP escalation the solve runs at a ~ 5 % gap on purpose (tightening backfires — it times out and returns a worse incumbent), with a feasible-floor guarantee so the incumbent is buildable and within ~ 1 – 2 % of the optimum. A **lock-optimality probe** (pin roof PV to 0 and confirm constraining can't beat the free optimum on the MILP's market objective) guards every value-shifting change.

10. Outputs & the bankable report

`/api/feasibility` returns the recommended sizes (with honest zeros), each component's NPV contribution, the 20-year NPV / simple + discounted payback / IRR vs the baseline, **self-consumption %** (locally-used on-site generation $\div$ total on-site generation) and **self-sufficiency %** (locally-used generation $\div$ total electricity demand — household load + new and existing heat-pump/resistance electricity + EV + elpatron), both reflecting the WHOLE system (existing BBR-registered PV threaded through generation and the baseline, so the percentages are not new-PV-only), CO2 avoided, the **systemvenlighed (Rc)** score (how well the property's net grid exchange correlates with the windy/cheap/low-CO2 signal, per smartvarme.dk), and the hourly dispatch series for the charts. The emailed **BankReport** is the same React report the user sees, captured to PDF client-side — so the bank's document is byte-for-byte what was on screen.

11. Recent methodology improvements (this revision)

Reason audit and price basis (October 2026):

- **Prices from the last 12 complete months**, rank-mapped onto the 2023 weather hours per (month, hour of

day), the window carried into the cache key (§3).

- **A home battery serves the building** (no grid-to-grid trading), one battery wear model (15 years or 6000 cycles), 0.5 C power everywhere (§8).
- **The inverter is a decision of the optimisation**, priced in the ranking as well as the result (§8).
- **No design is beaten by its own sub-designs**: drop-one dominance after every solve, and an NPV floor that tries sub-designs before "build nothing" (§8).
- **The risk band is centred on the analysis' own price basis**, so the headline is its central case (§8).

Earlier revision:

Deployed in the current revision (on `origin/main`):

- **A — DAWA retired; Datafordeler is the sole geometry source**, with the API key now mandatory at startup. (*commit 1e091b6*)
- **B — Geometry unified (ONE TRUTH)**: address/parcel/building geometry fetched once in EPSG:25832 and reprojected for the map, so the drawn parcel/buildings and on-parcel flags match the economics. Fixed addresses (e.g. Vesterbrogade 144D) that reported roof solar but showed no placement diagram. (*1e091b6*)
- **C — Placement diagram decoupled from roof-PV feasibility**: roof planes drawn whenever a footprint exists; the optimiser still places no PV on a forbidden roof. (*1e091b6*)
- **D — Real roof orientation from DHM**: per-building roof form/ridge/tilt from Danmarks Højdemodel (DSM/LiDAR) with the gable-default footprint heuristic as fallback. (*commit 77e3324*)

The one-command `scripts/ship.ps1` (gate `_quicktest` → commit → build/deploy → push → verify prod) runs the discipline gate before every release.

12. Limitations & honesty (what a professional should still flag)

- **Perfect-foresight optimism (financial, not just sizing)**. The dispatch knows the whole year's weather and prices, so the reported **NPV, payback and IRR are upper bounds** a real controller will not fully realise (chiefly battery/EV/thermal-store arbitrage). A ~10–15 % haircut / rolling-horizon re-dispatch is the next realism lever and is **not yet applied**; the same optimism drives some big-build tendency.
- **Roof geometry is a measured-but-heuristic classification**. DHM gives the real LiDAR surface, but the flat/gable/hip label, ridge bearing and tilt are a tuned classifier (FLAT_RELIEF, GABLE_LINEARITY, a 12–55° tilt clamp); near-square/multi-wing/courtyard roofs are approximated, only the $\geq 25 \text{ m}^2$ / 16-largest buildings get DHM (others use the footprint default), and relief currently uses a top-vs-low percentile that resists neighbours outside the footprint — a high-percentile/outlier-robust refinement against in-footprint chimneys/trees, geometric ridge validation, and a local-gradient tilt are planned.
- **Heat-pump sizing** targets ~average heat, not the $-12 \text{ }^\circ\text{C}$ design-day peak (cold-day peak → resistance).
- **Solar-thermal** yield uses a fixed-mean-fluid ($\sim 45 \text{ }^\circ\text{C}$) EN-12975 curve with no storage-temperature feedback — a calibratable pre-feasibility estimate.
- **Small wind** uses a 50 m effective height, a generic power curve and a flat 0.85 availability derate — a deliberately simple stand-in for an emerging product, not a certified turbine curve.
- **Process/ventilation load** for barns/commercial is a $\text{kWh/m}^2/\text{yr}$ estimate, not metered.
- **Sub-design dominance is tested one component at a time** (drop-one, repeated): a design that only a simultaneous swap of two components would improve is not searched; the MILP's own ~5 % gap still applies to the sizes of the components that stay.

- **DSO/tariff** is best-effort (no free address→grid-area→GLN lookup exists) and shown as approximate; the **financing rate** is a configured realkredit reference (live StatBank lookup planned). **DMI** live temperature is a UI nicety only — the calculation uses the coherent PVGIS series.

13. Sources & references

Public data (all free, commercial-use-OK; accessed/verified 2026-06):

- **Datafordeler** — distribution platform (SDFI / Klimadatastyrelsen) for: Adressevælger/DAR & Danmarks Højdemodel (Klimadatastyrelsen), Matriklen2 (Geodatastyrelsen), GeoDanmark (GeoDanmark-partnerskabet), BBR. <<https://datafordeler.dk>> · DHM WCS: <<https://datafordeler.dk/dataoversigt/danmarks-hoejdemodel-dhm/dhm-wcs/>>
- **BBR — Bygnings- og Boligregistret** (kommunerne / Bolig- og Planstyrelsen). <<https://teknik.bbr.dk>>
- **Danmarks Højdemodel (DHM/Overflade, DHM/Punktsky)** — Klimadatastyrelsen. <<https://confluence.sdfi.dk/pages/viewpage.action?pageId=25722920>>
- **PVGIS v5.3** — Photovoltaic Geographical Information System, European Commission Joint Research Centre. <https://re.jrc.ec.europa.eu/pvg_tools/en/>
- **Energi Data Service** — Elspotprices, DatahubPricelist, CO2Emis, ProductionConsumptionSettlement, ConnectionPointsInGrid. Energinet. <<https://www.energidataservice.dk>>
- **Global Wind Atlas** — DTU Wind Energy (CC-BY 4.0). <<https://globalwindatlas.info>>
- **DMI Open Data (metObs)** — Danmarks Meteorologiske Institut. <<https://opendatadocs.dmi.govcloud.dk>>
- **Danmarks Statistik — StatBank** (reference for the planned live realkredit-yield lookup; not yet wired). <<https://www.statbank.dk>>
- **Plandata.dk** — zonekort, forsyningsområde/varmeplan, lokalplaner. Plan- og Landdistriktsstyrelsen. <<https://plandata.dk>>
- **Beskyttede områder & fredede/bevaringsværdige bygninger** — Vejdirektoratet "Grunddata" / Miljøportalen / FBB (Slots- og Kulturstyrelsen). <<https://kort.vd.dk>> · <<https://www.kulturarv.dk/fbb/>>
- **Naturbeskyttelsesloven, Planloven, Bygningsfredningsloven, Varmeforsyningsloven** — Retsinformation. <<https://www.retsinformation.dk>>
- **smartvarme.dk** — systemvenlighed / vindvenlighed (Rc) concept. <<https://smartvarme.dk>>
- **PyPSA** — single-node sector-coupling model reference. <<https://pypsa.org>> · **HiGHS** solver. <<https://highs.dev>>

14. Reproducing this document

This PDF is generated from its Markdown source, so it stays diffable and in sync with the codebase:

```
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