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Innovation Pilot report - Loop 1 - Group 58

Company Proposal for Roskilde Municipality

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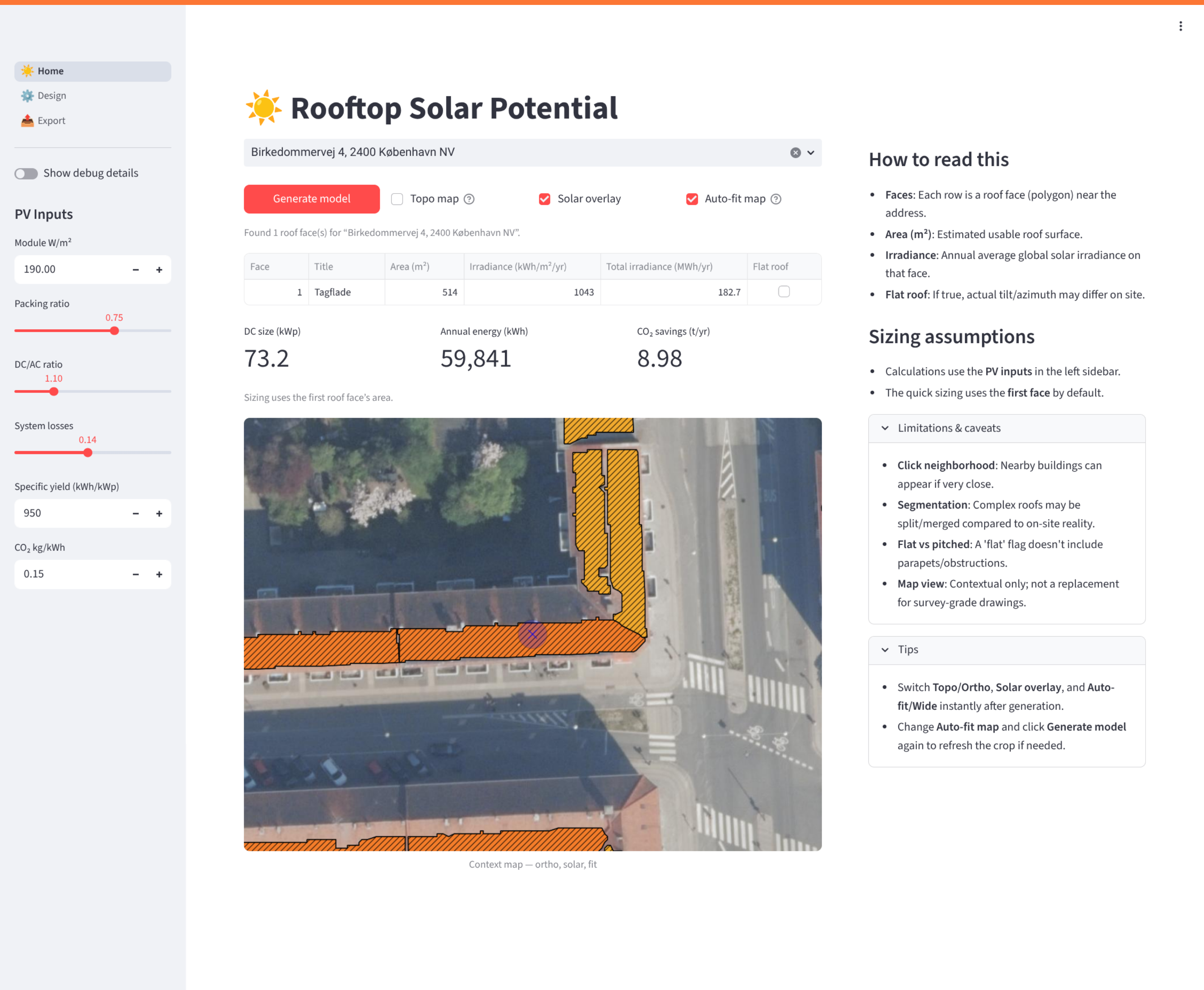

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1 Executive summary

Conclusion & recommendation: Pilot an MVP of the *Solar Readiness Brief* (see section 4.5) with 3-5 housing associations in Roskilde. The MVP produces a two-page, decision-ready brief per address, with transparent assumptions and citations, simple economics, and 8760-based self-consumption bands. In parallel, collaborate with Roskilde Municipality on building stock portfolio screening.

Success criteria: time-to-brief $\leq$ 5 minutes; annual-yield accuracy within ± 15% vs. references; ≥ 30% conversion from brief to pilot/quote.

The problem: Boards in housing associations lack *comparable, decision-ready* material to evaluate rooftop PV and energy-community options. Data is scattered across public tools, causing delays, inconsistent assumptions, and stalled initiatives. Residents also lack a credible, General Assembly (GA)-ready brief to place PV on the agenda.

Proposed solution: A web-based *Solar Readiness Brief* that turns any address into a two-page, source-linked pre-feasibility note in minutes. The brief reports indicative PV capacity and annual yield, 8760-based self-consumption/export bands, simple CAPEX/OPEX and payback, plus clearly stated assumptions and data lineage. The same engine supports *portfolio screening* so municipalities can surface and prioritise high-potential roofs.

Benefits for key stakeholders:

- **Housing association boards**
  - **Faster decisions:** decision-ready brief per address in $\leq$ 5 minutes; easy inclusion on GA agendas.
  - **Comparable & trusted:** standardised assumptions with sources and ranges enable apples-to-apples comparisons.
  - **Lower pre-tender risk:** clear CAPEX/OPEX and payback shorten quote cycles with installers/EPCs.
- **Roskilde Municipality**
  - **Portfolio view:** screen and prioritise high-potential roofs citywide.
  - **Consistent & report-ready:** harmonised method; CSV/PDF outputs for climate-plan KPIs.
  - **Operational efficiency:** earlier coordination with the distribution system operator (DSO) on expected PV capacity/export, and fewer information requests from citizens and boards.

Authorship note: Generative AI was used as a writing aid throughout this document for drafting and editing. The authors reviewed and verified all content and accept full responsibility for the results.

2 Introduction

In light of the ongoing green transition and the global challenge of mitigating climate change, Roskilde Municipality has positioned itself as an active participant in sustainable development by joining the C40 network of climate-leading cities. This commitment entails an ambition not only to reduce CO_2 emissions, but also to foster local resilience and sustainable energy consumption patterns.

A central aspect of this ambition is the creation of energy communities—local collaborations where citizens, businesses, and public actors collectively produce, share, and consume renewable energy. These communities can contribute to decentralized energy production, increase local supply security, and strengthen social cohesion through shared ownership and responsibility.

However, despite the technological readiness of renewable solutions such as solar panels, wind turbines, heat pumps, and energy storage systems, the pathway towards widespread establishment of energy communities remains complex. It involves navigating organizational models, regulatory frameworks, and financial mechanisms that must align to create attractive and accessible participation opportunities. The municipality thus faces a multifaceted challenge: to design structures that enable citizens and local stakeholders to engage meaningfully in the energy transition while maintaining economic feasibility and administrative clarity.n offer.

3 The Hard Nut

Through our analysis, we have identified “the hard nut” of Roskilde Municipality’s challenge: the perceived complexity, bureaucracy, and limited economic incentive associated with forming energy communities.

For many citizens, the idea of joining or establishing an energy community appears daunting. The regulatory framework surrounding collective energy production is often seen as difficult to interpret, and the processes for obtaining permits, connecting to the grid, and managing shared ownership structures are perceived as time-consuming and bureaucratic.

Furthermore, the economic benefits for individual participants are not immediately evident. While energy communities can contribute to long-term sustainability and independence from traditional energy suppliers, the upfront investment costs and uncertain payback periods often discourage participation. Without clear, tangible financial advantages or simplified procedures, citizens and small businesses may lack motivation to engage.

This combination of administrative complexity and modest short-term financial gain represents the core obstacle—the hard nut—that must be cracked for Roskilde Municipality to successfully promote and scale energy communities. Addressing this requires both systemic simplification and improved communication of the collective and individual benefits such communities can offer.

4 Proposal

4.1 Problem statement

Boards of andelsboligforeninger / boligforeninger in Roskilde struggle to take the first step toward forming energifællesskaber (energy communities) and investing in rooftop photovoltaics (PV). Today, information is fragmented across public registers and platforms, and boards often lack the time and analytical skills to combine these sources into credible, comparable pre-feasibility economics.

The result is slow or abandoned initiatives, "ping-pong" with installers for basic numbers, and GA (General Assembly) agendas without decision-ready material. A neutral, address-specific, source-linked brief with transparent assumptions and confidence bands is needed to move from idea → pilot/tender. Residents also need a way to self-start by producing the same decision-ready brief for the board. At municipal scale, a portfolio view is needed to surface high-potential roofs (especially where roof renovation is due) so outreach and pilots can be prioritised.[1, 2, 3, 4]

4.2 Stakeholders

- **Housing association boards** — make GA decisions on capital expenditure (CAPEX). Pain: lack of time, fragmented data, inconsistent assumptions. Need: concise, neutral pre-feasibility briefs (address-specific economics, assumptions, confidence bands) they can include in GA packets.
- **Residents (including ildsjæle)** — initiate ideas and seek board attention. Pain: no credible, shareable numbers. Need: a self-service path to generate a proposal-ready brief and email/share it with the board.
- **Property administrators** — support boards with numbers and compliance. Pain: manual data collection, unclear data lineage. Need: source-linked briefs and comma-separated values (CSV) exports they can archive and reuse across sites.
- **Installers/EPCs (Engineering, Procurement & Construction)** — provide quotes and designs. Pain: incomplete inputs and repeated clarification. Need: a standardised, address-specific brief that speeds up quoting and reduces back-and-forth.
- **Municipality (energy/climate and permitting)** — pursues climate targets and pilots. Pain: hard to identify and prioritise candidate roofs. Need: portfolio screening (including likely roof-renovation timing) and a transparent audit trail for engagement.
- **Distribution System Operator (DSO)** — grid connection. Pain: early requests without context. Need: basic site parameters up front so interconnection discussions start on solid ground.
- **Public data providers** — publish authoritative datasets. Pain: misuse/misinterpretation. Need: clear citation and retrieval dates in briefs to maintain trust.
- **Funders/banks** — support financing when projects mature. Pain: non-comparable estimates. Need: consistent, source-linked pre-feasibility numbers that can be diligence-checked later.

4.3 Vision

A self-service pre-feasibility portal that converts any Roskilde address into a decision-ready brief in minutes. The brief is address-specific and source-linked, with transparent assumptions and confidence bands, so boards can move from idea to pilot/tender and residents can credibly approach the board.

In addition to single-site use, the portal provides a portfolio screening mode to surface high-potential roofs across the municipal building stock and housing associations. Using public registers (e.g., BBR and related datasets), it can flag buildings likely nearing roof renovation (based on building age, roof material, and time since last recorded works), making them especially suitable candidates with lower incremental CAPEX when integrating PV (shared scaffolding, mounting integration). Each brief exports as a two-page PDF for GA packets and installer outreach, with a built-in share/email action for residents and comma-separated values (CSV) export for administrators

4.4 Evidence from desk research

We conducted desk research using publicly available sources to answer exactly what the Proposal needs: can we produce a neutral, address-specific pre-feasibility brief and a lightweight portfolio screen from public data only?

4.4.1 Scope & limitations

No interviews or field studies. The brief is indicative pre-feasibility (not an engineering design). Findings are triangulated across two or more sources where possible. Building-level smart-meter data is not available via public APIs; for MVP we use representative/segment-level load shapes with sensitivity bands and can swap in bills/meter data during quote/pilot.

4.4.2 Key findings

- Public data is sufficient to auto-generate a decision-ready, address-specific brief. Key sources include:
  - DAWA — https://dawadocs.dataforsyningen.dk/ (authoritative address lookup/-geocoding; stable IDs for joins)
  - Datafordeler (BBR, DAR, Matriklen) — https://datafordeler.dk/ (building, address, and cadastral [property/parcel] registers)
  - sologvindinfo.dk — https://www.sologvindinfo.dk/ (per-roof solar potential for indicative PV sizing and yield)
  - Energi Data Service — https://energidataservice.dk/ (day-ahead prices DK1/DK2, CO_2 intensity, aggregated consumption/production, network/transmission tariff datasets)
- Representative load profiles informed by Energi Data Service context are adequate for MVP; we present ranges and explicitly state assumptions.
- Many housing associations operate behind a shared main meter, supporting the early focus on associations and simplifying self-consumption accounting in initial phases.
- A neutral, source-linked presentation with assumptions and confidence bands differentiates the brief from installer calculators and reduces back-and-forth during quoting.
- Portfolio screening is feasible; BBR attributes (build/alteration year, roof material) can be used as proxies to flag likely roof-renovation timing. These are signals, not confirmations, and require board verification.
- For MVP, sologvindinfo.dk substitutes for custom PVGIS modelling.

4.5 Proposal outline

Build a web-based "Solar Readiness Brief" for housing association boards and residents. The user enters an address, the tool aggregates public data, and it estimates PV capacity (kWp), annual yield (MWh/yr), self-consumption, export, Capital Expenditure (CAPEX), Operating Expenditure (OPEX), and simple payback. It then generates a two-page PDF for decision-making and installer outreach.

Each brief includes an assumptions panel, data lineage (source and retrieval date), and confidence bands to make uncertainty explicit. A built-in call to action lets residents email the brief to their board, while administrators can export a comma-separated values (CSV) file to prioritise sites and coordinate installer quotes.

Beyond single-site reports, the portal supports portfolio screening of Roskilde's municipal building stock to identify high-potential candidates for energy communities. Using public registers (e.g., BBR and related datasets), the tool can also flag buildings that are likely approaching roof renovation based on building age, roof material, and time since last recorded major works. These sites are especially suitable candidates because boards are already focused on the roof decision and the incremental CAPEX of integrating PV (shared scaffolding, mounting integration) is typically lower. Outreach to selected boards can be handled via GDPR-compliant email using the auto-generated brief and summary metrics, enabling targeted engagement without manual compilation.

4.5.1 Needs it fulfills for stakeholders

- **Boards:** Faster, trustworthy pre-feasibility for General Assembly (GA) decisions. The brief provides plain-language results, an assumptions panel, and data lineage (source and retrieval date), reducing back-and-forth with administrators and installers. Example KPI: time-to-brief $\leq$ 5 minutes; GA-readiness score from user testing $\geq$ target.

- **Residents:** A concrete path to initiate projects: enter an address $\rightarrow$ generate an address-specific brief $\rightarrow$ use the built-in email call-to-action to send it to the board. The shareable PDF helps place PV on the GA agenda without technical jargon. Example KPI: share-to-board rate; % of resident-generated briefs that become GA agenda items within one cycle.

- **Roskilde Municipality:** A scalable pipeline of qualified projects. Portfolio screening highlights high-potential rooftops across the municipal building stock; comma-separated values (CSV) exports support prioritisation and coordination of installer quotes. The process is GDPR-compliant and creates a transparent audit trail through explicit data lineage. Example KPI: number of qualified sites per screening run; proportion progressing to request for quotation (RFQ)/pilot.

- **Regulatory & ESG:** Support for energy-community formation and local generation while preserving trust. Transparency (assumptions, confidence bands, sources) and privacy practices (no personally identifiable information beyond address) align with GDPR and relevant electrical/building codes and DSO interconnection guidance. Example KPI: compliance checklist completion; % of briefs with complete source citations.

4.5.2 Decision rationale

This tool is not limited to housing associations. It can screen businesses, public buildings, and detached homes as well. For this Minimum Viable Product (MVP) we focus on housing associations where activation is most straightforward. Estimates are produced with segment-specific models (load shapes, tariffs, metering/settlement rules), so results will differ by building type.

Why housing associations first:

- Information and capacity gap — boards often lack the time, focus, and analytical skills to combine public datasets into credible economic estimates. The portal's concise, source-linked feasibility briefs close this gap and make GA discussions actionable.

- Established governance and decision authority — boards and committees are already in place with clear decision rules; General Assemblies (GAs) can authorise capital expenditure (CAPEX) in a single vote. A shared property and cost base aligns member priorities and simplifies orchestration of an energy community.

- Favourable roof-to-load match — large, contiguous roofs and aggregated common-area loads raise on-site self-consumption and improve payback; block-scale geometry also reduces shading-model uncertainty.
- Streamlined metering and settlement — many associations sit behind a shared main meter, enabling straightforward self-consumption accounting in early phases and avoiding per-apartment meter upgrades in the MVP.

Other segments Energy communities that share energy across the public distribution grid face common constraints: network tariffs and fees on exchanged energy; metering and settlement requirements; and the need for an appropriate legal/governance setup between participants. Moreover, auto-generating a reliable feasibility brief is harder for heterogeneous, geographically separated member groups, and portfolio screening/optimisation across multiple addresses is computationally intensive.

Businesses:

- **Pros:** Complementary, offsetting load profiles (e.g., offices by day, hospitality in the evening, cold storage overnight) can lift portfolio self-consumption (a key KPI); larger rooftops and predictable operating hours simplify sizing.
- **Cons:** Limited access to site-level interval data; roof ownership/lease splits; tenancy churn shifts loads; approval chains across facilities and finance slow decisions.

Public buildings:

- **Pros:** Portfolio scale and relatively stable loads; alignment with public climate targets; ability to bundle sites.
- **Cons:** Procurement law; annual budget cycles; heritage/listed-building constraints; cross-department coordination that extends timelines.

Detached homes:

- **Pros:** Potential for street- or development-based cohorts with similar roof types; large aggregate rooftop area; strong community appeal.
- **Cons:** High variance in consumption and roof condition; aesthetic and neighbourhood constraints; one-to-one outreach economics; accuracy depends on access to smart-meter data.

4.6 Validation & MVP targets

Planned methods

- Benchmark outputs against trusted references: compare portal yield and sizing against sologvindinfo.dk and at least one established PV tool for representative rooftops; spot-check geometry via DSM/DTM and orthophotos.
- Run sensitivity analyses on key drivers: tariffs (Energi Data Service), representative load profiles, PV CAPEX/OPEX ranges, and export/self-consumption assumptions; report bands in the brief.
- Sanity-check economics against installer quotations when available and verify interconnection assumptions with DSO guidance.

- Lightweight usability tests with target users (board members, residents/ildsjæle, administrators): measure time-to-brief, comprehension of assumptions/confidence bands, and share-to-board flow.

MVP targets

- Usability: System Usability Scale (SUS) ≥ 70. Time-to-brief ≤ 5 minutes. Task completion in tests $\geq 90\%$.
- Technical accuracy: annual yield error within $\pm 15\%$ vs reference (sologvindinfo.dk or equivalent). Economics within $\pm 20\%$ of installer Total Cost of Ownership (TCO) where quotes exist.
- Adoption: $\geq 35\%$ of boards presented with a brief request a pilot/quote. $\geq 20\%$ of resident-generated briefs appear as GA agenda items within one cycle.
- Data quality & compliance: $\geq 95\%$ of briefs include source citations and retrieval dates. No personally identifiable information beyond address. Assumptions and confidence bands shown on every brief.

5 Prototype

This section documents the alpha version of the Solar Readiness Brief proposed in Section 4. The alpha version (early prototype) was presented as a live demo during the project presentation. An image of the UI is presented in Figure 1. The goal of the alpha version is to show an end-to-end, address-specific pre-feasibility flow that a board member or resident can use to assess rooftop PV potential for a single building.

- **Delivers today:** DAWA-backed address autocomplete and geocoding $\rightarrow$ sologvindinfo.dk roof faces and solar attributes $\rightarrow$ on-screen KPIs (DC kWp, annual energy, optional CO_2), plus an orthophoto map with a semi-transparent solar overlay.
- **Out of scope in this alpha version:** exports (PDF/CSV), data-lineage display, portfolio mode (restricted feature), 8760 load/self-consumption, and simple economics.

5.1 Feature status

Implemented in alpha version:

- DAWA-backed address autocomplete + geocoding to coordinates.
- sologvindinfo.dk roof faces + solar attributes fetched per selected address.
- Orthophoto map with solar overlay.
- Derived KPIs shown on screen: DC capacity (kWp), annual energy (kWh), optional CO_2 (t/year).
- Basic assumptions inputs with tooltips: power density, packing ratio, DC/AC ratio, and system losses.
- User enters address $\rightarrow$ review roof face(s) $\rightarrow$ on-screen KPIs (Generate brief renders on screen).

Missing in alpha version:

- PDF and CSV export, two-page brief with sources and assumptions.
- Data-lineage display in UI and exports (source names and retrieval dates).

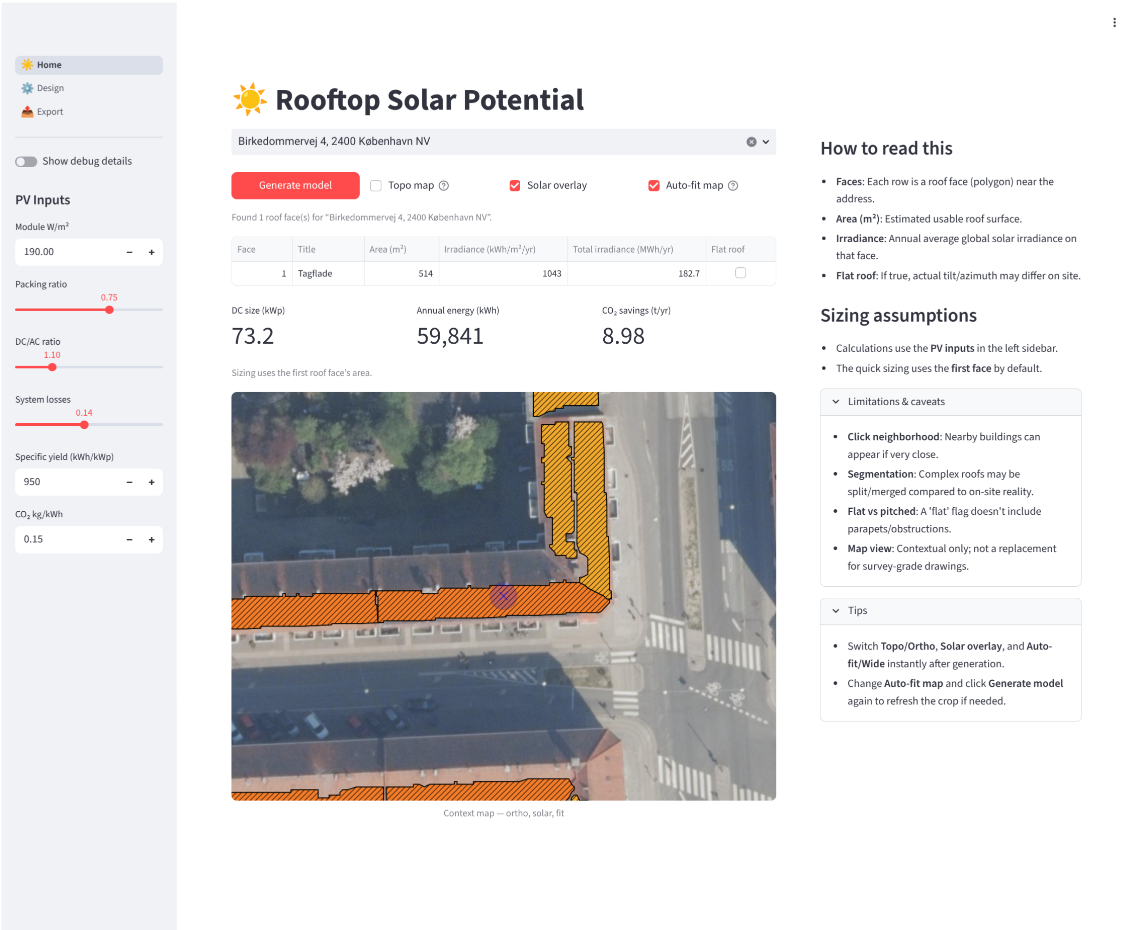

Figure 1: Alpha version UI: DAWA-backed address search, orthophoto map with solar overlay from sologvindinfo., and on-screen KPIs for a selected building.

- Portfolio mode, batch ranking with background jobs and caching.
- Representative 8760 load profiles, self-consumption and export simulation.
- Simple economics, payback with low/base/high bands, tariff and price inputs from Energi Data Service.
- Table $\leftrightarrow$ map linking, click a face row to select the polygon, and map click selects the row.
- Confidence bands on KPIs and charts.
- User flow: User enters address $\rightarrow$ brief $\rightarrow$ Export PDF / Copy link.
- Portfolio screening mode.

5.2 Architecture & data flow in alpha version

- **Pipeline:** Address $\rightarrow$ DAWA geocode $\rightarrow$ coordinates $\rightarrow$ sologvindinfo.dk roof faces and attributes $\rightarrow$ KPI calculation.
- **Sizing/yield:** derived from sologvindinfo.dk roof potential, presented as **indicative**.

6 Business and Economic Perspective

For private households in Denmark, the interest in solar panels has increased significantly in recent years, partly because the price of the solar panel system itself has fallen, and partly because electricity prices have been rising. An average estimate of the total costs of electricity for a private household today typically lies in the range of DKK 2.50–2.90 per kWh, including taxes, VAT, and grid tariffs. According to the Electricity Price Statistics from the Danish Utility Regulator, as reported by Elberegner.dk, the overall cost for a household consuming 4,000 kWh per year in the fourth quarter of 2024 was about DKK 2.90/kWh.[5]

This price is consistent with Statistics Denmark, which shows that the average electricity price for households in the first half of 2025 was around DKK 2.6/kWh including taxes and fees.[6] This price is the reason why many private households have been or may become motivated to reduce electricity consumption through self-consumption via solar panels on the roof.

The economic gain from a solar panel system naturally follows from how much of the electricity is used by the household itself, but also what can be earned from the surplus electricity. The part of the electricity that is not used in the household and is transferred to the grid is calculated at a fixed rate or based on market prices. Andel Energi offers a production agreement where surplus production is purchased at the spot price level, and in their calculations, DKK 0.55/kWh is used as a typical reference price.[7]

In addition, the grid tariffs also play a role in the overall economy. According to Energinet's forecast for electricity tariffs in the 2024–2026 period, tariffs are expected to rise as more energy will be used in society. More electric cars, heat pumps, and decentralized production mean that the electricity grid must handle greater loads and requires investments in infrastructure.[8]

Energinet has also stated that in the near future, they will harmonize tariff payments and introduce so-called real-time tariffing for producers of their own electricity, such as private solar panel owners. This means that one will increasingly be billed based on the actual times when electricity is produced and consumed, instead of an average over the whole day. The goal is to create a fairer and more efficient system that promotes flexible electricity use and reduces peak load periods.[9]

In summary, these economic conditions mean that solar panels for many households represent both a stable and manageable investment. A typical detached house with a system of about 4–6 kW can on average produce 4,000–6,000 kWh per year, of which about two-thirds can normally be used directly in the household. With the current electricity prices and settlement terms, this implies an annual saving of about DKK 5,000–9,000, of course depending on consumption pattern, roof size, and roof angle. 4–6 kW:[10, 11]

In a broader perspective, the spread of solar panels contributes not only to private economic benefits but also to a more sustainable local energy supply. For every citizen who produces their own electricity, the pressure on the electricity grid during peak load periods is reduced, and municipalities such as Roskilde can achieve a greener energy mix without becoming dependent on large, central plants. At the same time, it strengthens local business development, as more installers, electricians, and energy consultants get new tasks.

Solar panels are not only an economic advantage in some cases but a shared project for the coming years. It is an invitation to those citizens who want to help make a difference and who might only need the first argument to bring the idea to the board meeting or community meeting.

7 Further perspectives

Beyond the business and economic aspects of the project, Loop 1 has also been a valuable exercise in reflection on process, teamwork, and interdisciplinary collaboration. One of the most significant insights was how much the innovation journey depends on striking the right balance between divergent and convergent thinking. Early in the process, our tendency to converge too quickly limited creativity, but once we allowed more space for open exploration, our ideas became stronger and more diverse. This highlighted the importance of patience in the early phases of innovation, even when the problem feels urgent or complex.

Another key reflection concerns communication. Within the group, clear and open dialogue was crucial for maintaining alignment, especially as we came from different study backgrounds and worked with different ways of thinking. The interdisciplinary setup proved to be a real strength: software engineers contributed technical know-how, while engineering students from other fields brought analytical structure, creativity, and critical perspectives. This diversity created friction at times but ultimately led to a richer and more complete prototype than any one discipline could have produced alone.

We also realized the importance of maintaining stronger contact with external stakeholders. While we received valuable feedback from the municipality and facilitators, more continuous interaction could have sharpened our understanding of the real-world needs and expectations. In future projects, we will aim to integrate stakeholder communication as an ongoing part of the process, not only at the beginning and end.

Finally, this loop reminded us that the value of such projects lies not only in the solution produced but also in the skills and perspectives we develop along the way. We leave Loop 1 with a stronger appreciation for interdisciplinary teamwork, more awareness of how to structure an innovation process, and a better sense of how to balance technical feasibility with user trust and adoption. These additional reflections will be just as valuable in Loop 2, even though the project context will be entirely different.

8 Conclusion

Loop 1 has been an important opportunity to explore a complex real-world challenge and transform it into a concrete, actionable proposal. Starting from the broad ambition of Roskilde Municipality to foster energy communities, we identified the “hard nut” as the lack of decision-ready information for housing associations considering solar energy. Our prototype demonstrated that by leveraging publicly available datasets, it is possible to generate transparent, address-specific briefs that can support both citizens and boards in making informed decisions.

The economic analysis confirmed that rooftop solar is becoming increasingly attractive in Denmark, not only for individual households but also for municipalities striving toward sustainable energy targets. However, our work also revealed that technology alone is insufficient; adoption depends on clarity, trust, and the ability to communicate complex information in a simple and actionable way.

Although Loop 2 will focus on an entirely different project, the learnings from this loop remain highly relevant. We have gained experience in framing challenges around stakeholder needs, testing ideas through rapid prototyping, and ensuring transparency in data and assumptions. These methods and insights will help us approach future innovation projects with sharper focus, stronger stakeholder alignment, and a better understanding of how to translate technical feasibility into real-world adoption.

In this sense, the greatest outcome of Loop 1 is not only the prototype itself but also the transferable skills and perspectives it has given us. These will serve as a foundation for tackling new challenges in the next loop and beyond.

hello from me

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