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Harnessing solar power in the Alps: A study on the financial viability of mountain PV systems

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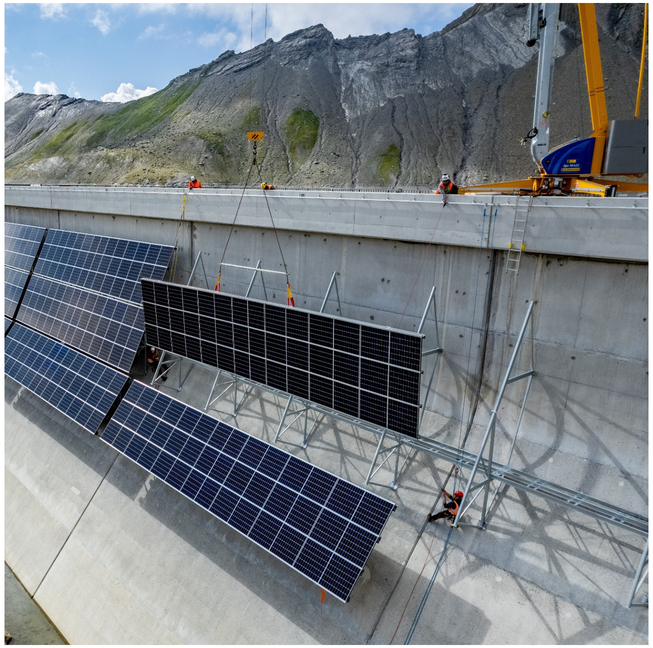
We investigate the profitability of three typical alpine PV project types (not the exact ones on the pictures)

Ground-mounted

Wall-mounted



Floating

Investment subsidy scheme to support large solar PV installations in the Alps, enacted in September 2022

Energy Law	
When	Yearly production **10 GWh**
	500 kWh / kWp in winter
Then	Easier permitting
	Coverage of up to 60% investment costs
But	Limited to the first **2 TWh**
	10% of plant connected until **end of 2025**

BFE | Calculation of subsidy

- BFE gives capital cost **(WACC*)** and electricity price assumptions
- The subsidy sets the **NPV**** of the project to **0**, but up to 60% invetsment cost

*WACC – Weighted Average Cost of Capital

**NPV – Net Present Value

Main research question:
Under these policy conditions, how profitable are alpine PV plants?

Method

Study design

a) 1st Stage **Structured interviews**	b) 2nd Stage **Financial modelling**
Identification of relevant technologies, costs and business models: a) Initial round of desktop research on existing and planned mountain PV in Switzerland b) Structured interviews with 13 mountain PV experts c) Follow-up round of desktop research on existing and planned mountain PV in Switzerland	Financial model for 6561 scenarios: a) First loop to size the subsidy using BfE power prices, financing costs and costs of capital assumptions b) Second loop to calculate the project IRR and equity IRR based on market power price data and financing cost assumptions

Structured interviews

Best-Case Scenario Costs for 15 MW Plant:

Bifacial modules

Location: Above 2000 m elevation

Access to road and grid infrastructure

Suitable surface (no rock substructures)

Stepwise Percentage Cost Increase for Worsening Project Conditions:

No Grid Access: +X% cost increase

No Road Access: +Y% cost increase

Unfavorable Ground Structure (e.g., rock substructures): +Z% cost increase

Complement Interviews with Desktop Research:

Review existing projects and their public announcements

Analyze project details, announcements, and outcomes

Financial modeling

Conditions (irradiation and investment costs)		Project types		Business Model		Financing
Favourable		Ground Mounted (15 MW)		**Captive Customer** (85 EUR/MWh, lifetime)		Project Finance
Moderate	X	Wall (2 MW)	X	**PPA** (79.5 EUR/MWh, 10y + merchant tail)	X	
Unfavourable		Floating (15 MW)		**Merchant** (wholesale market during lifetime)		Balance Sheet Finance

6561 scenarios

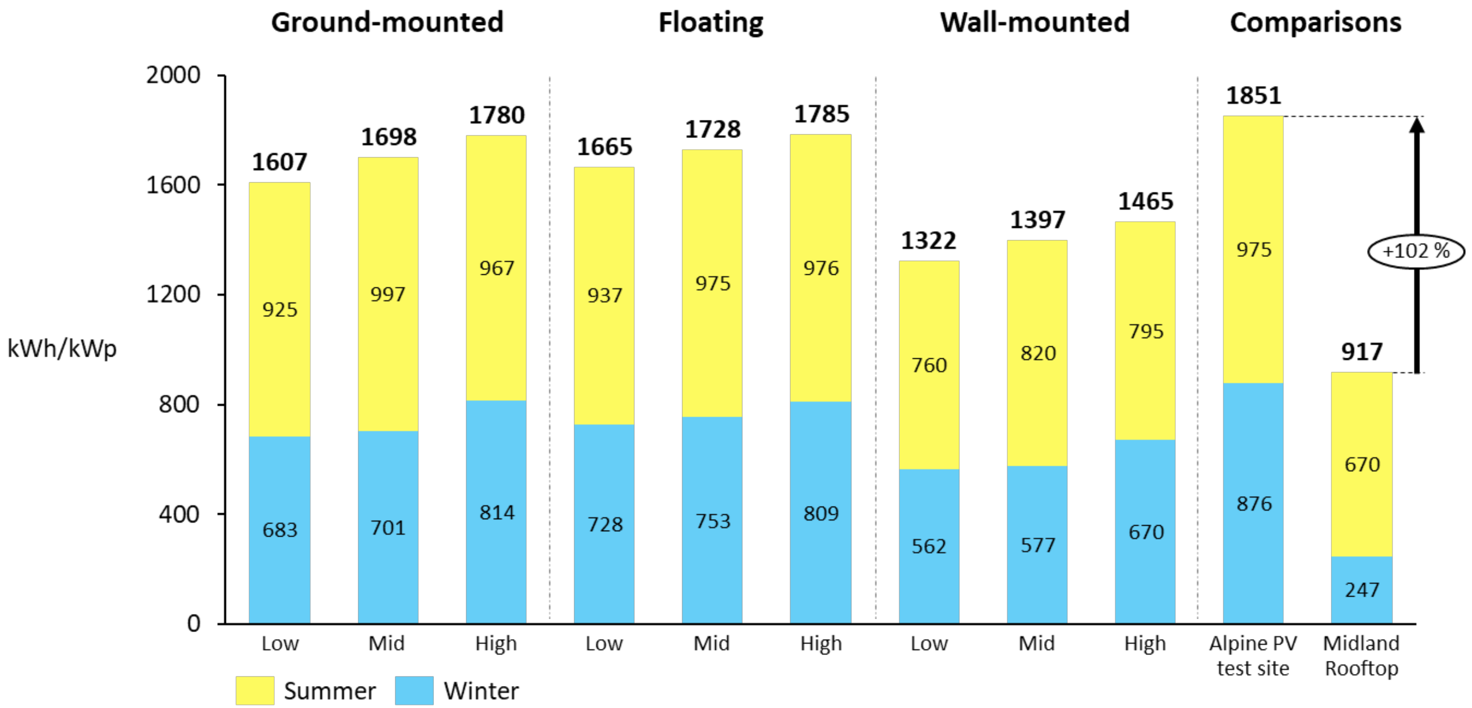
Step 1: using government set WACC of 5.23%, debt costs of 2.5% and power price assumption, calculate the subsidy amount so that sets the projects NPV to zero

→

Step 2: using the calculated subsidy and non-government price scenarios and financing assumptions to calculate project and equity IRR

Profitability: IRR above 5.23%

Solar irradiation assumptions



Source: own elaboration of Sunwell for locations suitable for alpine PV plants and ZHAW for the midland installation

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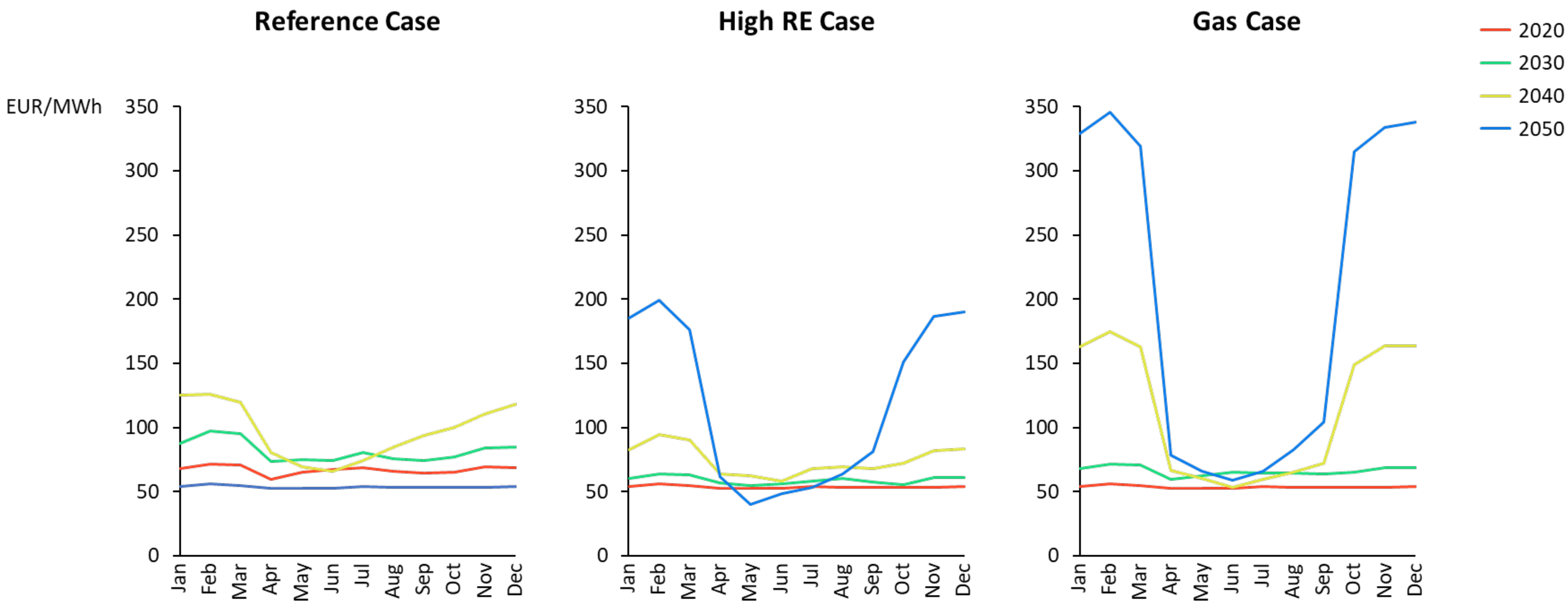
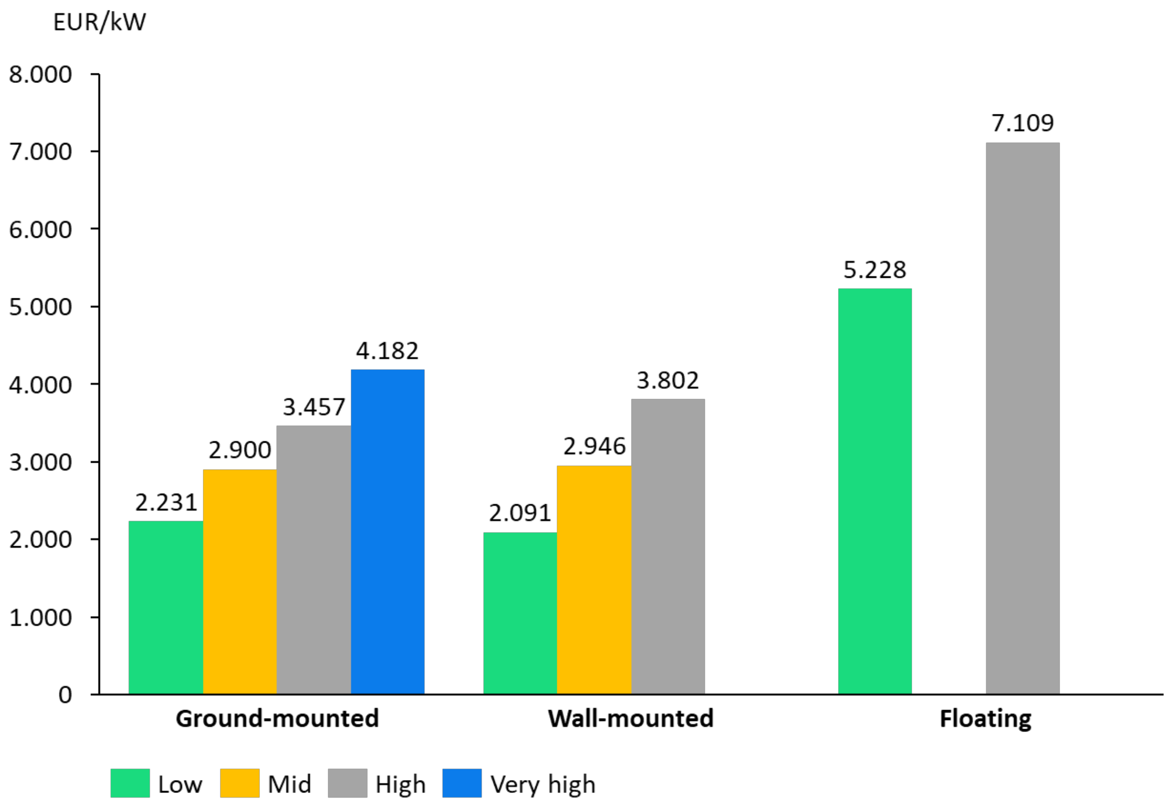
Price scenario assumptions



Source: EIP-ETH Collaboration Rethinking future Swiss electricity supply, 2024

Results

Investment costs based on survey with alpine PV project developers and investors. Values represent estimates. Ongoing project development reveals costs are higher than these levels for ground-mounted plants

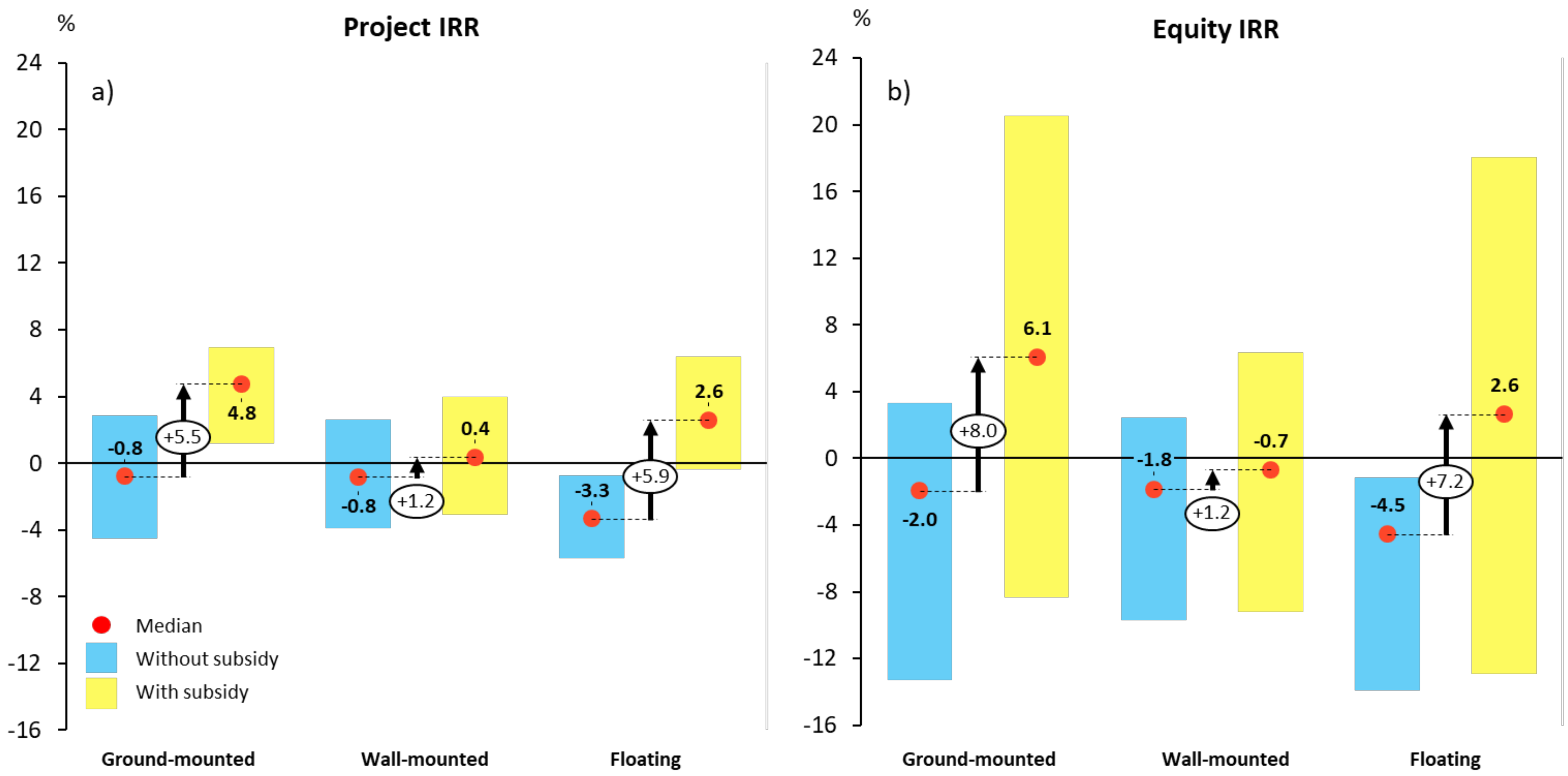


List of projects with known capacity and cost from public announcements, as of March 2024

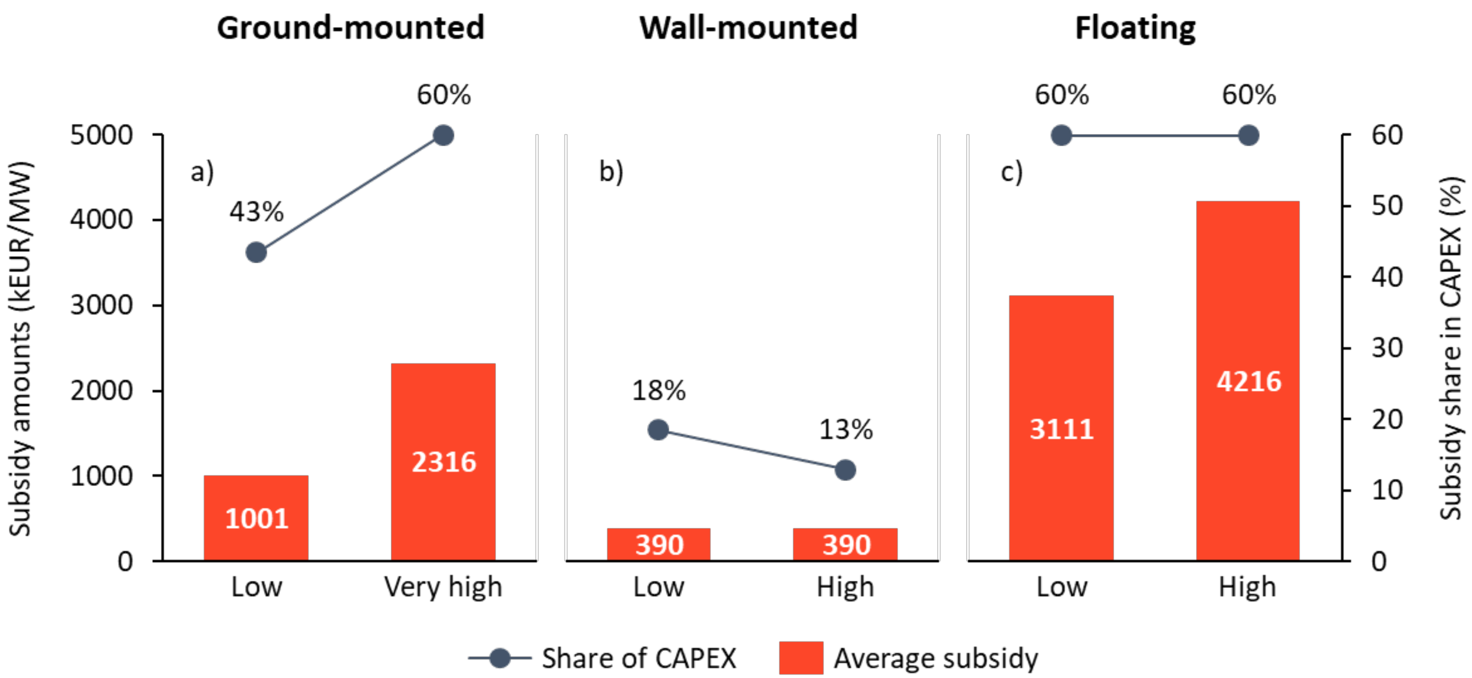
Project	Size (MW)	CAPEX (CHF)	CHF/MW	Developers
Solarprojekt "Morgeten"	8	17	2’014	Morgetensolar AG; Thun Solar AG; Energie Thun AG
Schwandfäl	11	37	3’325	BKW; LWA; Tschentenbahnen AG
Belpmoossolar	35	31	896	Flughafen Bern AG; BKW; ewb
PV Alpin Parsenn	8	40	4’784	Swisspower AG; EWD
Vorab	8	31	4’180	Repower; Gem Laax; Weisse Ar. Bergbahnen AG; Flims El
Madrisa Solar	12	45	3’745	Repower; Klosters-Madrisa Bergbahnen AG; Gem. Klosters
Ovra Solara Magriel	10	42	4’180	Axpo; Bergbahnen Disentis AG
SedrunSolar	18	63	3’426	Energia Alpina SA
Samedan	30	52	1’742	Energia Samedan; TNC Consulting AG
Scuol Solar	34	146	4’303	Gemeinde Scuol; EE, EKW
BerninaSolar	80	251	3’135	-
Grands Plans	11	24	2’138	Alpage du Marais; Bergbahnen Grimentz-Zinal; Oiken; Alpiq
GondoSolar	16	44	2’760	EES; Gemeinde Gondo-Zwischbergen; Renato Jordan
Vispertal Solar	30	125	4’180	Axpo; FMV; EnAlpin; Industrie Visp (Lonza, Arxada, DSM)
Grengiols Solar	92	392	4’260	Gemeinde Grengiols; EnBAG; FMV; EKZ; Groupe E; IWB

Mean ≈ 4000 CHF/MW

Ground mounted PV is the most profitable with median project IRR of 4.8% including subsidy and equity IRR of 6.1%. However, none of the project types would be viable without the subsidy

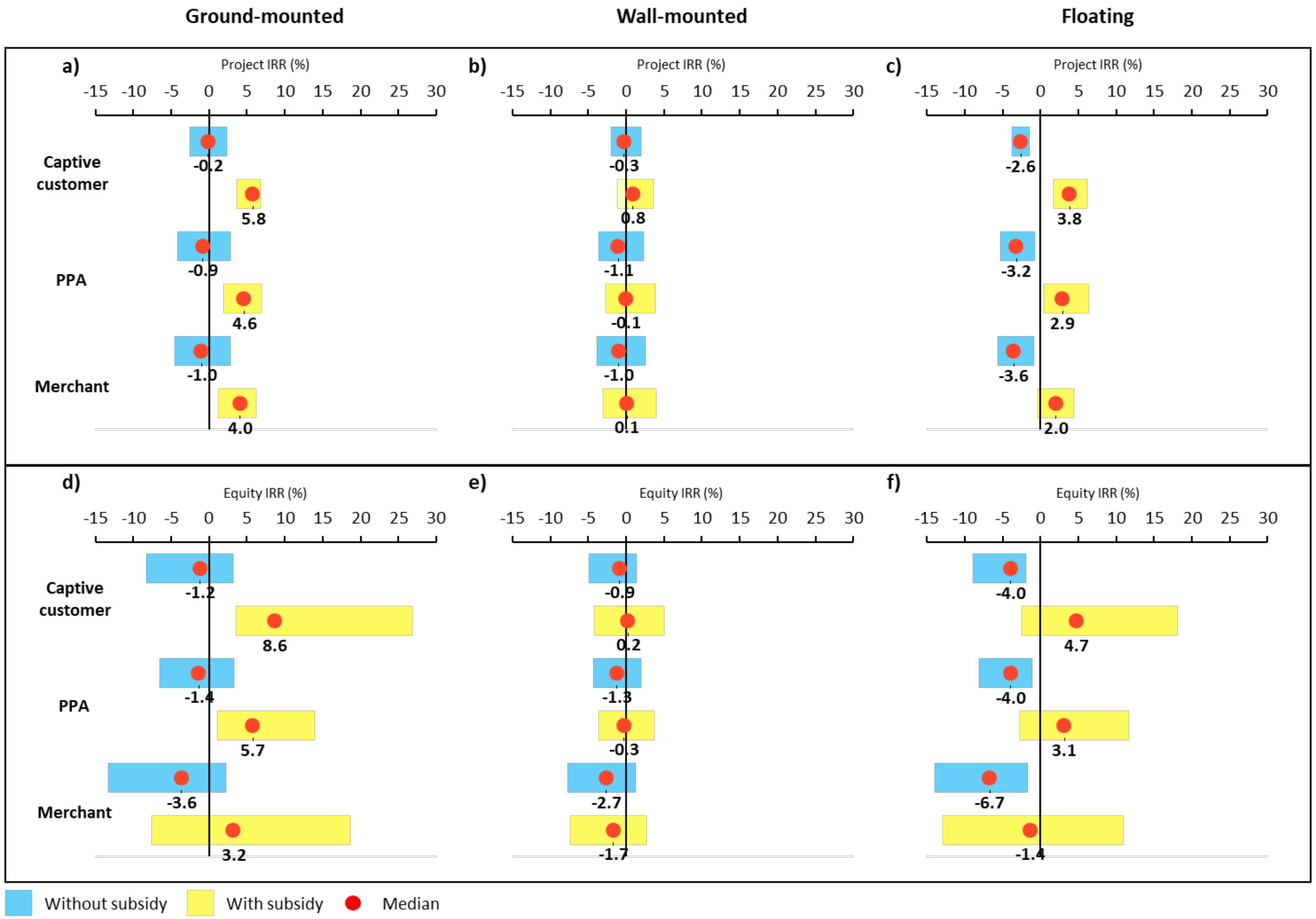


Higher investment costs increase the subsidy amount, because the subsidy us awarded up to 60% of costs, regardless of their level



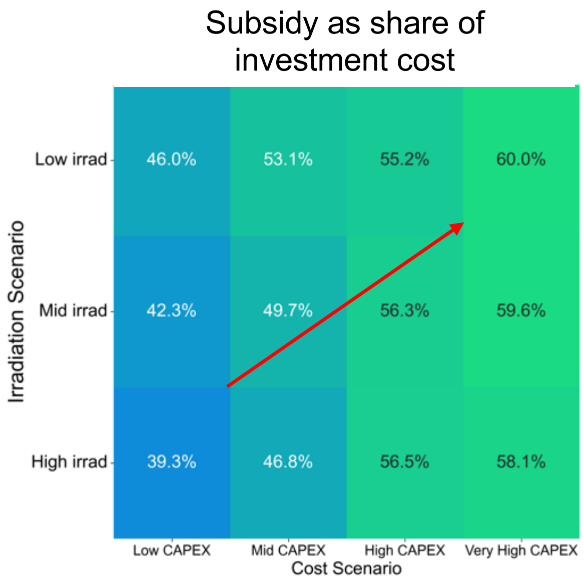
* wall-mounted projects do not quality for the same subsidy as ground-mounted and floating because of their smaller size, and their subsidy levels are generally lower

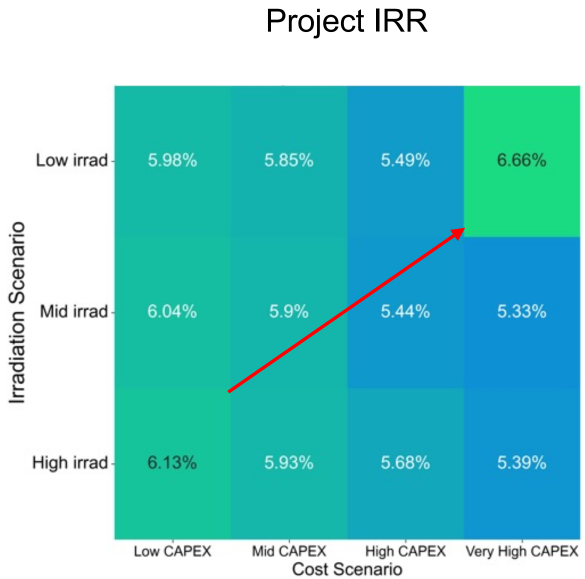
The captive customer business model leads to highest profitability with a mean project IRR of 5.8% with subsidies. The PPA model profitable only with low investment costs and high solar irradiation



Locational characteristics: the subsidy system awards higher subsidy amounts to projects in worse locations and leads to over-subsidisation

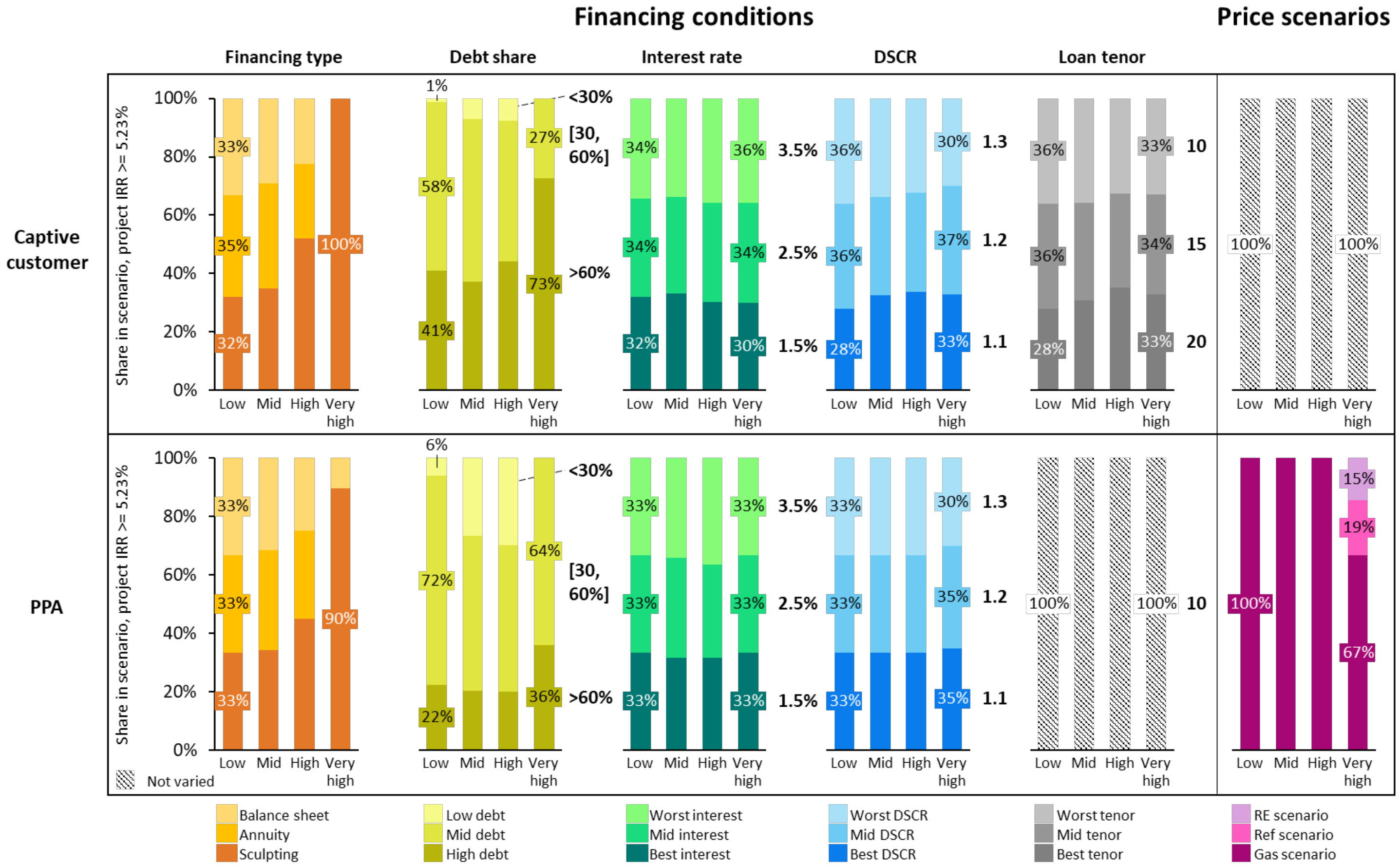
Deep-dive into ground-mounted PV





Financial characteristics: higher debt levels and sculpted debt repayment create more profitable outcomes, along with aggressive price scenarios

Deep-dive into ground-mounted PV



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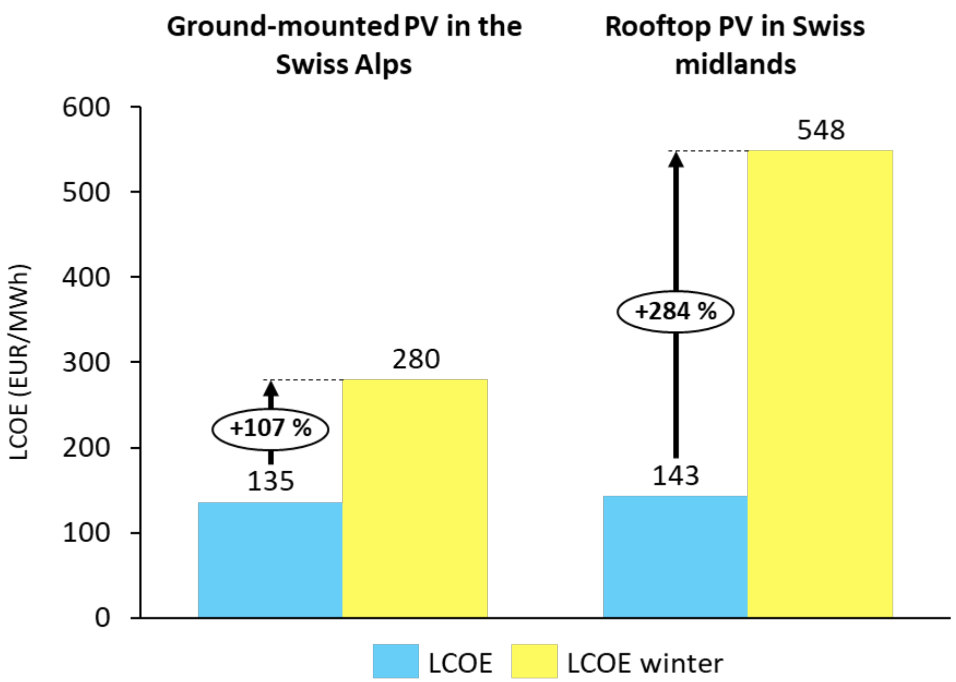
Alpine PV plants have comparable generation costs to midland plans owing to their two times larger production during wintertime

Deep-dive into ground-mounted PV



Conclusions

Main findings

1. CAPEX between 2231 EUR/kW and 4182 EUR/kW (based on Spring 2023 interviews) for ground-mounted projects and up to 3802 EUR/MW for wall-mounted and 7108 EUR/MW for floating PV
2. Ground mounted projects the most profitable with median equity IRR levels of 6.1% after subsidies, which are between three and six times higher than for wall-mounted and floating projects
3. Necessary subsidy levels depend mainly on CAPEX costs, varying between 43% and 60% share in investment costs for ground-mounted projects with low and very high CAPEX levels, respectively. Less cost-effective projects awarded more subsidy, leading to inefficient public spending
4. Captive customer business model is the most profitable, leading to median project and equity IRRs of 5.8% and 8.6% for ground-mounted projects, respectively, assuming subsidies.

Policy implications

Is the current investment subsidy scheme the most suitable for supporting large-scale renewable energy projects?

- No. The scheme is insensitive to cost-effectiveness, meaning that even the most expensive projects can receive 60% subsidy if they are quickly realized.
- Replacing investment subsidies with sliding premiums (two-sided Contract for Difference), awarded via auctions could lead to more cost-effective support allocation and is a system widely used in Europe, for instance for large scale offshore wind. Here nuances are important, for instance, would the government help with site development like for offshore wind etc.
- The investment subsidy favors utility captive customer business models, because these offer the longest revenue security. However, not everyone has access to electricity customers, willing to pay for green electricity. Revenue stability in form of Contracts for Difference is crucial to broaden the investor landscape.

Thank you for your attention!

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The modeling framework