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Solar potential analysis of gridconnected ski lifts



Context and objectifs

With their high total annual PV output (over 1500 kWh/kWp in the canton of Valais¹) and high winter production, the exploitation of Alpine PV potential is promising. Nevertheless, the location of photovoltaic systems in remote areas must be carefully selected, as sustainable energy production should be achieved with the least possible impact on the environment. Locations near ski lifts have two major advantages: the existing electrical infrastructure and their self-consumption. The aim of this analysis was to identify ski lift sites for potential solar installations based on a case study with different types of demand profiles. The aim was to establish a guidline for ski lifts for their PV installation options. In order to maximize profitability, the study examined the self-consumption and self-sufficiency rates to determine the potential independence of the ski lifts from the electrical grid and the amount of energy consumed or fed back into the grid. The area of five ski resorts in the canton of Valais form the core of the case study. [1] Solargis

Analysis of consumption, production potential and electrical infrastructure

1. Geographic location and site choice

2. Consumption profiles

1) Lodge, arrival station and restaurant



Fig. 1: Sites close to transformers were chosen for the potential analysis. The ski areas were excluded using OpenSnowMap and only unobstructed sites without trees were retained. In total, 60% of the sites were retained. [2] vsgis.ch, [3] swisstopo.admin.ch

46.26 46.24 46.22 Latitude 46.20 Transformers - Ski lifts 46.18 46.16 46.14 7.65 7.50 7.55 7.60 Longitude Fig. 2: Map^{2,3} of LV/MV transformers with an estimated power of 360-576 kW.

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From the possible sites identified in 1., **three sites** with different load profiles were chosen for the case studies:

1) Lodge, arrival station and restaurant 2) Chairlift, arrival station and restaurant 3) Surface lift

Year 2021 was excluded for the economic analysis.



Fig. 3: Load profiles of the three sites

3. PV production simulation with pylib and Solcast

1) Lodge, arrival station and restaurant 1) Lodge, arrival station and restaurar PV south PV south PV east PV east



4. Economic cost-benefit analysis for feed-in scenarios

	Annual Production (MWh/year)	Self- consumption rate	Autarky rate	LCOE (ct/kWh)
1) PV South	405	0.45	0.54	9.5
1) PV East-West	533	0.35	0.56	8.7
2) PV South	499	0.48	0.65	9.3
2) PV East-West	525	0.44	0.62	8.8
3) PV South	491	0.10	0.95	10
3) PV East-West	536	0.09	0.88	7.7

rates



2) Chairlift, arrival station and restaurant



3) Surface lift



Fig. 4: PV production at the three sites for different panel orientations

Number of panels	750				46.4	Fig. 7: Distribu	ution of s	ki lift typ	es and th	neir average pow
Number of rows	5		South		46.2					
Height above ground	1.5 m	1)) 294 kW (13.02.2021 13:1	5)	2 4		Number of sites	PV production South	PV production East/West	
Distance between rows R		2)) 360 kW (12.02.2022 13:3	46.0 -		Fribourg		(GWh/year) 8.6	(GWh/year) 9.2	
Module Height L 1.038 m Ground coverage ratio L/P 0.2						Jura	1	0.4	0.4	
Inclination	round coverage ratio L/R 0.2 Inclination 90° (vertical)				6.0 6.5 7.0 7.5 8.0 8.5 Longitude		Nouchâtol	12	4.6	5
Orientation	180° (south) 90°/270°	1)) 288 kW (12.04.2021 09:1	5)	Fig. 6: Geographical distribution o	ſ	Valais	260	128.8	138.6
	(east/west)	2)) 284 kW (10.04.2022 09:0))	ski lifts in Romandy		Vaiais	200	120.0	22.0
PV panel type	Himalaya M6 Series HuaSun	3]) 301 kW (13.04.2021 08:0))	SKI III I Komanay			12	30.0	32.9
							TOLAT	500	172.9	180.1
Tab. 1: Simulation parameters Tab. 2: Maximum PV production				Tab. 4: Extrapolation of case study results to Roman						
Next steps				Conclusions						
Mesure PV aravalanches Include fixa losses depen Calculate PV reduce row c	V production) with at least 5 tion cost, elected ding on distant V production p distance.	in potential 5 modules per ctrical connec ice to LV/MV ootential taking	locations on technology. tion and cable transformers. g into account	fixations (e.g transmission	 The average yearly energy studies was 495 MWh in so direction, for PV installation The most profitable option range, according to the site set of the set of the	y production uth-facing di s sized to the was self-con specific energie come profita	obtain rection peak p sumpti sy dem ble afte	ned ac and 5 ower c on, eit and. er few y	eross t 33 MV of 360 P her in vears.	he three ca /h in east-we cW. the LV or N
		More detail	Is on the analysis can be found in 'Le	solaire alpin des remontées méca	niques: Lorsque profitabilité rime avec protection', Rémy Gabioud, Bachelor	hesis HES-SO, 2023.				.set

47.4

47.2

47.0

46.8

Number of rows Height above ground Distance between rows F Module Height L Ground coverage ratio L/ Inclination	5 1.5 m 5 5 1.5 m 1.038 m 1.038 m R 0.2 90° (vertical)	1) 2) 3)	South 294 kW (13.02.2021 13:15) 360 kW (12.02.2022 13:30) 360 kW (14.02.2021 12:45) 50% East / 50% West		46.2 46.0 6.0 6.5	7.0 7.5 8.0 8.5 Longitude		Fribourg Jura Neuchâtel	Number of sites22113	PV production South (GWh/year)8.60.44.6	PV production East/West (GWh/year) 9.2 0.4 5
PV papel type	(east/west)	1) 2)	284 kW (10.04.2021 09.13)		Fig. 6: Ge	Fig. 6: Geographical distribution of ski lifts in Romandy			260	128.8 30.6	138.6 32.9
	HuaSun	3)	301 kW (13.04.2021 08:00)			U		Total	368	172.9	186.1
Tab. 1: Simulat	Tab. 1: Simulation parameters Tab. 2: Maximum PV production				Tab. 4: Extrapolation of case study results to Roma						
Next steps			Conclusions								
 Mesure PV production in potential locations on fixations (e.g. baravalanches) with at least 5 modules per technology. Include fixation cost, electrical connection and cable transmission losses depending on distance to LV/MV transformers. 			 The ave studies v direction The most 	rage yearly energy vas 495 MWh in sou , for PV installations t profitable option	production uth-facing dir sized to the was self-con	obtai rection peak p sumpti	ned ac and 53 ower o on, eitl	ross t 33 MW f 360 k her in	he three /h in east cW. the LV o		
reduce row distance.			 PV installations at ski lifts become profitable after few years. 								
		More details on	the analysis can be found in 'Le solaire	e alpin des remontées mécar	I niques: Lorsque profitabilité ri	me avec protection', Rémy Gabioud, Bachelor Th	esis HES-SO, 2023.				

Fig. 5: Scenarios for economic analysis

	Panel orientation	Injection mode	LV/MV
1)	East-West	Self-consumption	MV
2)	South	Self-consumption	MV
3)	South	Self-consumption	LV

Tab. 3: Best case scenarios with summer/winter tariff

5. PV potential of ski lifts in Romandy



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