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Solar potential analysis of grid-connected ski lifts

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Context and objectifs

With their high total annual PV output (over 1500 kWh/kWp in the canton of Valais[1]) 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

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

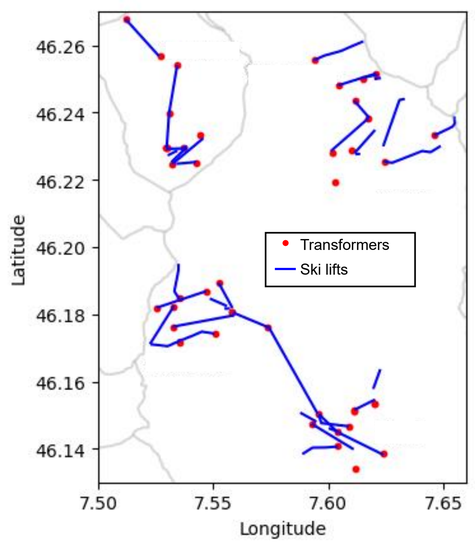

Fig. 2: Map[2,3] of LV/MV transformers with an estimated power of 360-576 kW.

2. Consumption profiles

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.

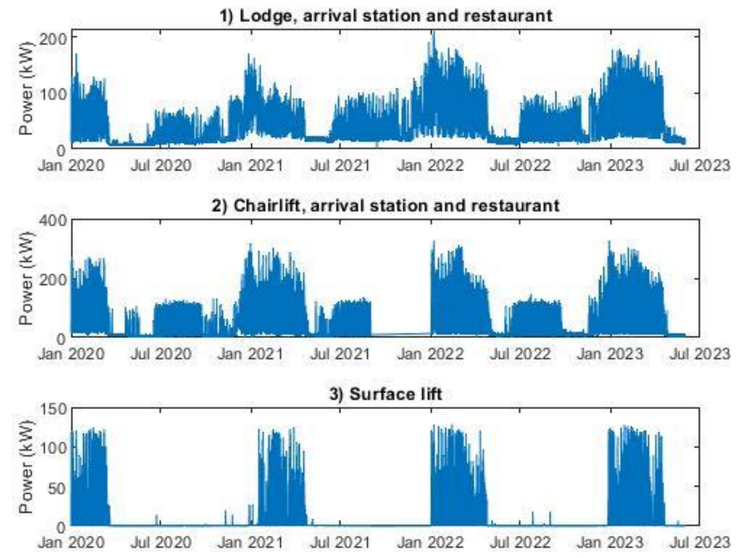

Fig. 3: Load profiles of the three sites

3. PV production simulation with pvlib and Solcast

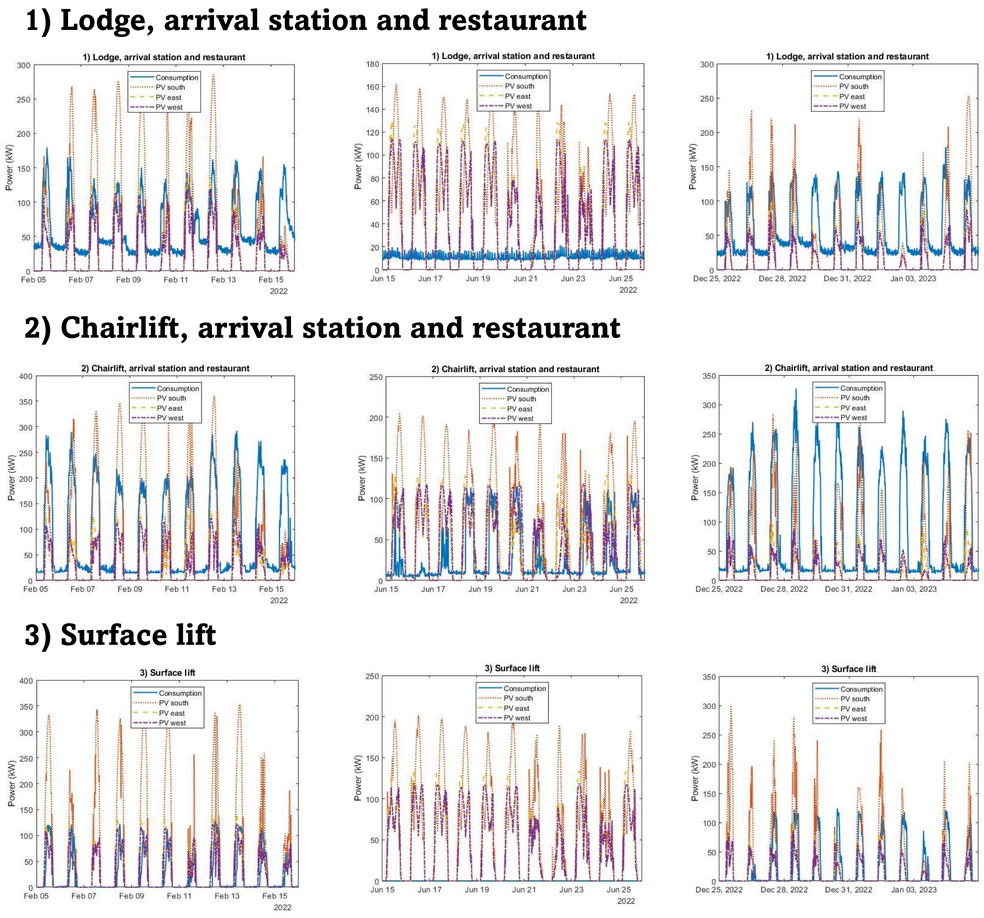

Fig. 4: PV production at the three sites for different panel orientations

Number of panels	750
Number of rows	5
Height above ground	1.5 m
Distance between rows R	5 m
Module Height L	1.038 m
Ground coverage ratio L/R	0.2
Inclination	90° (vertical)
Orientation	180° (south) 90°/270° (east/west)
PV panel type	Himalaya M6 Series HuaSun

Tab. 1: Simulation parameters

	South
1)	294 kW (13.02.2021 13:15)
2)	360 kW (12.02.2022 13:30)
3)	360 kW (14.02.2021 12:45)
	50% East / 50% West
1)	288 kW (12.04.2021 09:15)
2)	284 kW (10.04.2022 09:00)
3)	301 kW (13.04.2021 08:00)

Tab. 2: Maximum PV production

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

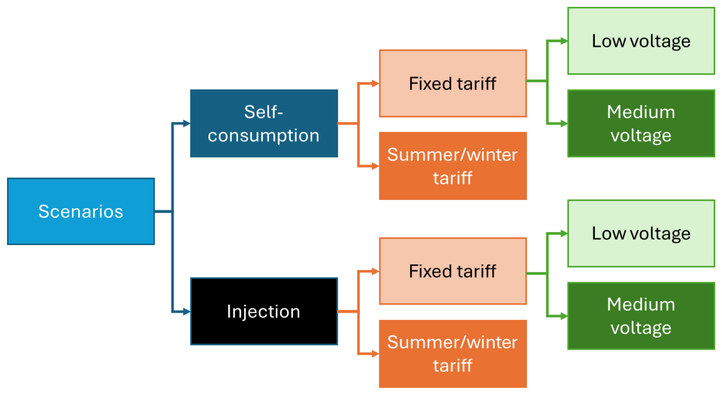

Fig. 5: Scenarios for economic analysis

	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

Tab. 2: Self-consumption and autarky rates

	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

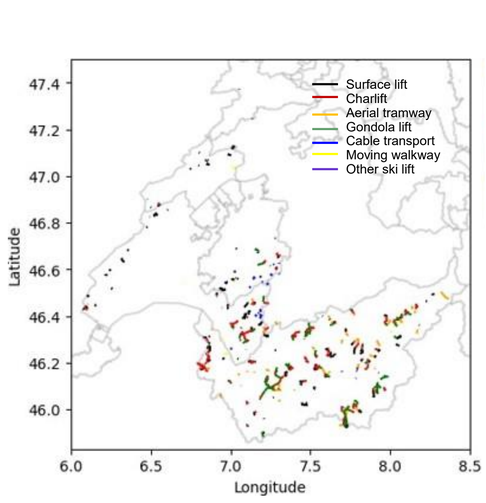

Fig. 6: Geographical distribution of ski lifts in Romandy

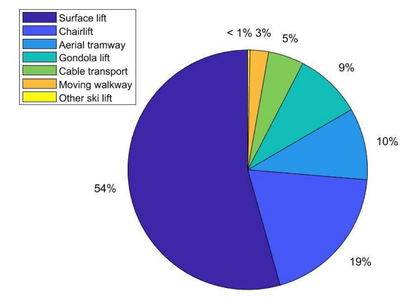

Fig. 7: Distribution of ski lift types and their average power

	Average power (kW)
Surface lift	110
Chairlift	337
Gondola lift	567
Aerial tramway	627

	Number of sites	PV production South (GWh/year)	PV production East/West (GWh/year)
Fribourg	22	8.6	9.2
Jura	1	0.4	0.4
Neuchâtel	13	4.6	5
Valais	260	128.8	138.6
Vaud	72	30.6	32.9
Total	368	172.9	186.1

Tab. 4: Extrapolation of case study results to Romandy

Next steps

1. Mesure PV production in potential locations on fixations (e.g. paravalanches) with at least 5 modules per technology.
2. Include fixation cost, electrical connection and cable transmission losses depending on distance to LV/MV transformers.
3. Calculate PV production potential taking into account topography to reduce row distance.

Conclusions

- The average yearly energy production obtained across the three case studies was 495 MWh in south-facing direction and 533 MWh in east-west direction, for PV installations sized to the peak power of 360 kW.
- The most profitable option was self-consumption, either in the LV or MV range, according to the site specific energy demand.
- PV installations at ski lifts become profitable after few years.

More details on the analysis can be found in 'Le solaire alpin des remontées mécaniques: Lorsque profitabilité rime avec protection', Rémy Gabioud, Bachelor Thesis HES-SO, 2023.