

Snowmaking in Austria: Resource Consumption and Greenhouse Gas Emissions

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Ski Tourism: Status Quo & Global Warming

Ski Tourism

- Global: 150 million skiers and 366 million skier visits (Vanat, 2025)
- Austria: Third largest global ski tourism market with 50.1 million skier visits (13.7 % of global volume) (WKO, 2025; Vanat, 2025)
- Austria: Economic importance of winter sports tourism. 5.9 billion Euros gross value added, creating 125,900 jobs (MANOVA, 2019)
- Austria: Cultural significance
3 million skiers – participation rate of over 30%, one of the highest in the world (Vanat, 2025)

Global warming

- Winters in Austria have warmed by 1.7°C since pre-industrial times (Olefs et al., 2021)
- Snowmaking: Important adaptation strategy in ski tourism (Knowles et al., 2023; Steiger et al., 2021)

Scientific Discourse and Research Gaps

- Scientific (and public) debate on snowmaking: Topics include the consumption of resources (water and electricity) and its greenhouse gas emissions. (Knowles et al., 2023; Heuser, 2022; WKO, 2019)
- Is snowmaking a suitable adaptation strategy or is it maladaptation which further accelerates global warming? (Knowles et al., 2023)
- There is not yet a single questionnaire-based study worldwide that has collected data directly in ski resorts on resource consumption (water and energy) and greenhouse gas emissions from snowmaking. (Knowles et al., 2023; Steiger et al., 2021)
- We follow the call by Steiger et al. (2021, p.1) to seek for "better knowledge of the status quo" of ski tourism greenhouse gas emissions.

Research Questions

- 1. What are the key figures of snowmaking intensity and resource consumption?**
- 2. What factors influence resource consumption of snowmaking?**
- 3. What is the total annual demand for electricity and water and the related carbon emissions for snowmaking in Austrian ski tourism as a whole?**

Methods and Sample

- Questionnaire created using expert interviews
- Sent to 141 ropeway companies in Austria
- 6 defined ski seasons: 2014/15 to 2018/19 (before Covid-19-pandemic) and 2022/23 (after Covid-19-pandemic)
- Data from 30 ski resorts → from very small to medium-sized to very large
- Sample includes: 17.8 million skier visits
→ 34.0 percent of the Austrian ski tourism volume (WKO, 2025)

Extrapolation of the sample:

- Regression calculations, variable: Kilometers of slopes with snowmaking facilities
$$\text{LN (Elect/Wat/NbSnm)} = \alpha + \beta_1 \times \text{LN (SKESM)}$$

Results: Key figures of snowmaking intensity and resource consumption

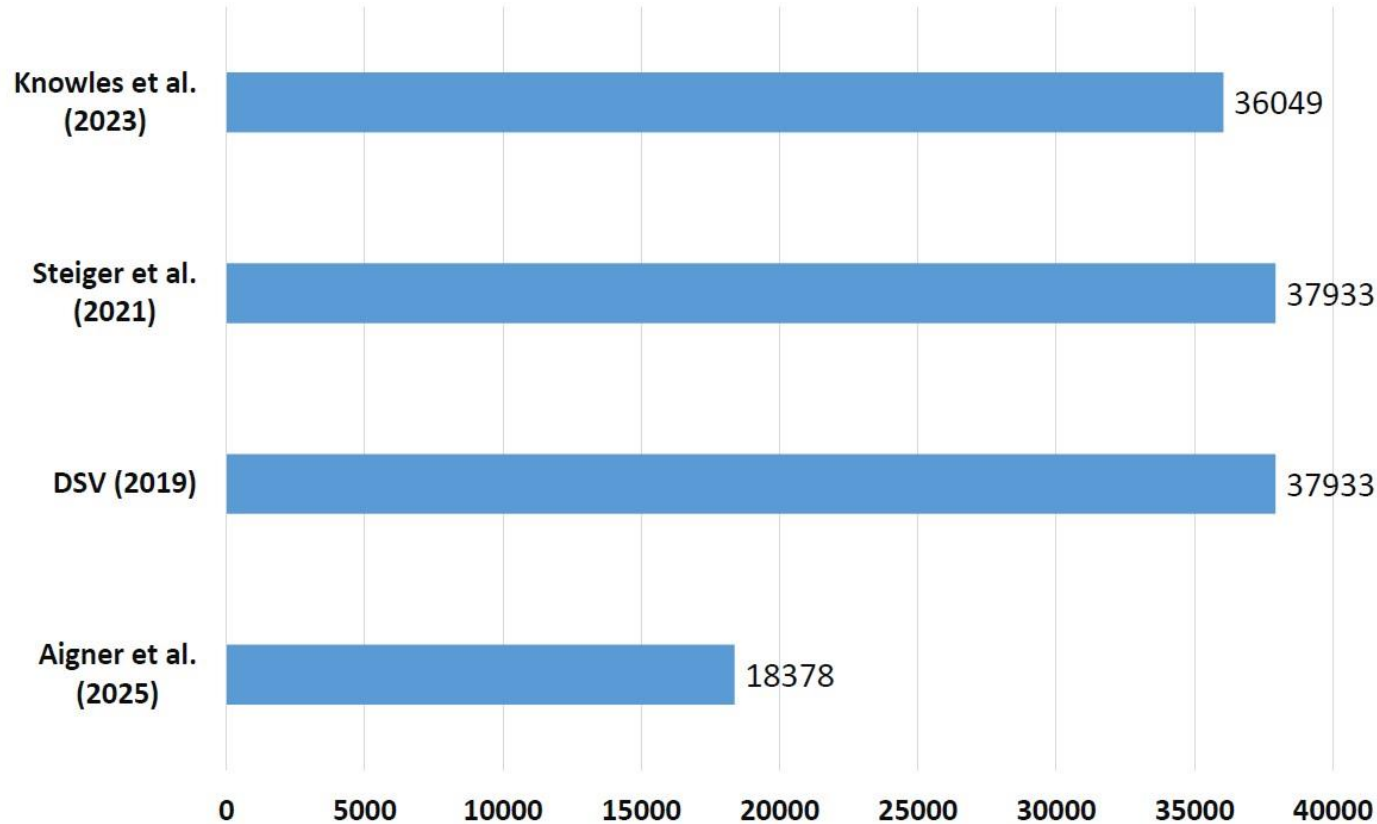
▪ % of slope km equipped with snowmaking facilities	86.5	
▪ Snowmakers per ha per 1,000 skier visits	2.9	0.8
▪ Ratio of lances to fan guns	43.0 : 57.0	
▪ Water turnover in m ³ per ha of slopes Water column in cm:	3,254	32.54
▪ Water turnover per skier visit in liters:	963.8	
▪ Electricity input in kWh per ha of slopes per skier visit:	18,378	5.5
▪ Electricity input to produce 1 m ³ of snow in kWh:	3.3	
▪ Average operating hours per snowmaker per season in h:	184.6	
▪ Average thickness of snow cover on the slopes in cm (factor: 1:1.75)	56.9	
▪ Snow in m ³ produced per skier visit	1.69	
▪ Percentage of snow produced with renewable energy contracts	99.9	
= Percentage of snow produced by companies that have signed a contract for the exclusive use of renewable energy		

Results: Total annual resource consumption and carbon emissions (Austria)

- **Water turnover** **48.9 to 53.4 million m³**
- **Electricity requirement** **260 to 309 GWh**
- **Carbon emissions**
 - (1) Average Austrian energy mix (209 t CO_{2e}/GHW) **54,395 to 64,651 t CO_{2e}**
Umweltbundesamt (2025) Per Skier Visit: 1,150 g
 - (2) Hydropower emissions factor (24 t CO_{2e}/GHW) **6,246 to 7,424 t CO_{2e}**
International Hydropower Association (2022) Per Skier Visit: 132 g
 - (3) Renewable energy emissions factor (10 t CO_{2e}/GHW) **2,603 to 3,093 t CO_{2e}**
Umweltbundesamt (2024) Per Skier Visit: 55g

Discussion

Snowmaking:
Energy consumption in kWh for a slope thickness of 56.9 cm



Energy

- 18,378 kWh/ha for 56.9 cm snow pack
- 5,5 kWh/skier visit
→ driving 25 km with electric car
(Stadtwerke Konstanz, 2025)
- Annual energy demand for snowmaking in Austria:
260.3 to 309.3 GWh
→ 355 to 950 GWh per season
(Steiger et al., 2021)

Discussion

Water

- 3,254 m³/ha → 5,305 m³ (Knowles et al., 2023) ; 2,648 m³ (WKO, 2023)
- Annual water demand for snowmaking in Austria: 48.9 to 53.4 million m³
→ *But: Water used for snowmaking goes back to natural cycle* (Steiger et al., 2021)

Carbon Emissions

- Highly dependent on assumed emissions factors
- Per Skier Visit: 55g to 132g to 1,150g CO_{2e}
- Car drive with diesel powered car: 0.4 km to 0.9 km to 8.1 km
(Bundesministerium für Klimaschutz, 2023)

Management Implications

- The figures identified in this study can objectify the debate about snowmaking, and serve as benchmarks for future resource & cost savings for ski resorts.

Limitations

- It was very difficult to obtain data:
 - 1) Lack of transparency
 - 2) Surprising lack of data availability | technical controlling
- The construction of the snowmaking systems is not included in the calculations

Conclusion

- The figures circulating in the literature regarding the energy consumption of snowmaking appear to be too high.
- The influence of snowmaking on global warming is probably overestimated.
- Amazing insight: Many ski resort operators don't even know how much resources their snowmaking consumes.

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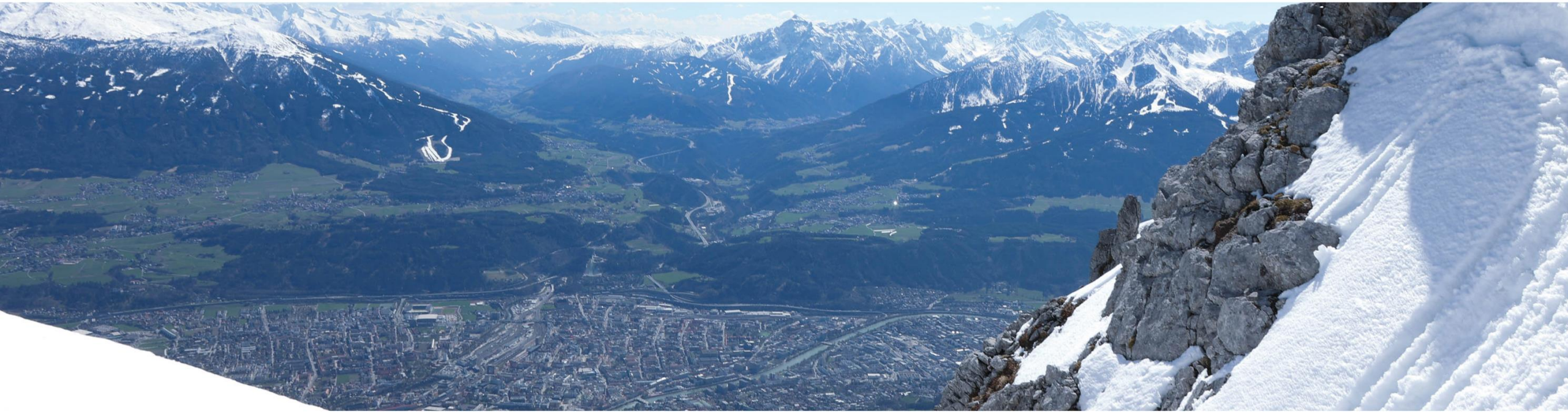
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