Snowmaking in Austria

Greener and more sustainable than assumed?

Empirical data: Water – Energy – CO_2 Emissions

Paper for PhD – University of Innsbruck (AUT) – Preliminary findings

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Introduction

Snowmaking: Adaptation to Climate Change

- Winters in Austria have warmed by 1.7 degrees Celsius since pre-industrial times (Olefs et al., 2021, p. 23)
- Duration of winters: Snow cover period shortened by 40 days since 1961, especially below an altitude of 1,500 meters (ZAMG, 2022)
- Pressure on ski tourism → adaptation measures → increasingly powerful snowmaking systems (Steiger & Mayer, 2008)

Social and scientific debate on snowmaking

… has been taking place for decades. Topics of conflict include:
→ use of resources **(energy, water)**
→ Ecological footprint of snowmaking **(adaptation or maladaptation?)** (Scott et al., 2022) and skiing (Die ZEIT, 2022)

Today's presentation: Preliminary findings

… from a study at the University of Innsbruck (Austria) for the *Management* PhD program

Introduction

Research Gap

- No evidence-based study on the resource consumption of snowmaking – neither in Austria nor worldwide
- Hardly any knowledge about greenhouse gas emissions from snowmaking

Research questions

- What is the annual demand for electricity and water for snowmaking in Austria?
- What is its annual carbon footprint?
- What are the most important key figures, on average, across Austria that ski resort operators can use as a benchmark to improve their economic and ecological sustainability?

This study aims to

- improve the level of knowledge on snowmaking and thus,
- contribute towards a more economically and ecologically sustainable development of ski tourism.

Project Steps

- Unstructured interviews with experts from three ski areas

  … and with Professor Robert Steiger (University of Innsbruck)
  ... to find out which parameters are best suited for a questionnaire

- The questionnaire was then created and refined with the interviewees
- Questionnaire:
  → First part: structural data – e.g. skier visits, size of area equipped with snowmakers
  → Second part: consumption data – key figures used in the literature,
  e.g. water and energy consumption per hectare
- 141 companies in Austria contacted
- Investigation period: May 2023 to April 2024
- 12 months of active courting for data (ski resorts seem to be very communication averse when it comes to data)
- Ongoing plausibility checks
- 6 evaluated ski seasons:
  5 seasons before Covid (2014/15 to 2018/19) and the first ski season after the pandemic (2022/23)

Sample and Methods

- 30 ski areas achieved a data quality that meets the requirements of this study
- Data from 7 Austrian states (out of 9)
- Sample total: **4,253 hectares equipped with snowmakers**
- Sample total: **17.8 million skier visits** … which corresponds to a share of 34.0 percent of the Austrian skier visits (WKO 2023a)
- Mean sea level (of all mountain and valley stations): 1,439 m
    - 3 of the 28 ski areas were classified as very small (under 4 kilometers of slopes)
    - 3 ski areas are small (5 to 14 km)
    - 10 ski areas are medium-sized (15 to 49 km)
    - 7 ski areas are large (50 to 99 km)
    - 7 ski areas are very large (more than 100 km of slopes)

Methods

- Extrapolation of the sample. Variable: Skier Visits
- Calculated energy requirement per m^3 of water turnover: 6.45 kWh
- Assumed water to snow ratio: 1:1.75

Results – Total Numbers

Total annual water demand for technical snowmaking in Austria

→ Extrapolation per skier visits (52.5 million)

→ 43.8 million m³

Total annual energy demand for technical snowmaking in Austria

→ Extrapolation per skier visits (52.5 million)

→ 281 GWh

Austrian Association of Ropeways, September 2023:	**205 GWh** (WKO, 2023b, p. 63)
Estimates in scientific literature:	**355 to 950 GWh** (Steiger et al. 2021, p. 115-116)

Total annual CO2 emissions for technical snowmaking in Austria

→ Extrapolation per skier visits (52.5 million)

→ Greenhouse gas calculator (Umweltbundesamt 2024a)

→ Conversion with: (1) Renewable energy – 1 GWh = 10t (2) Austrian Power Mix – 1 GWh = 230t

→ 2,831 tonnes

Results – Key Figures

Total number of snowmakers	**35,924**
Ratio of fan guns to lances: 48.1 to 51.9 %	17,272 fan guns and 18,652 lances
Number of snowmakers per ha	2.9
Number of snowmakers per 1,000 Skier Visits	0.7
Average operating time	**174 h**
Km of slopes equipped with snowmakers, % of total km	**82.4 %**
Snow production from green energy	**99.9 %**
Water per ha of slopes equipped with snowmakers	**3,501 m³**
Energy per ha of slopes equipped with snowmakers	**22,449 kWh**
Energy per 1 m³ snow	**3.7 kWh**
Energy per Skier Visit	**5.3 kWh**
CO_2 per Skier Visit	**54 g**

= equal to 0.4 km driven with a gasoline powered car (Bundesministerium für Nachhaltigkeit und Tourismus, 2018)

CO_2 (in kg) per ha of slopes equipped with snowmakers	**226 kg**

Discussion: Electricity and CO_2

Power consumption

Snowmaking	Snowmaking, cable cars and lifts
➢ **281 GWh**	Approx. **843 GWh**
➢ = 0.44 %	= 1.32 %

… of the annual total electricity consumption in Austria: 63,700 GWh (Bundesministerium für Klimaschutz 2024)

CO_2 emissions

Snowmaking	Snowmaking, cable cars and lifts
➢ **2,831 t**	Approx. **8,493 t**
➢ = 0.0038 %	= 0.0116 %

… of the annual Austrian CO_2 emissions: 72.8 million tonnes (Umweltbundesamt 2024b)

→ Cable cars, ski lifts and snowmaking contribute *one ten thousandth* to Austria‘s annual CO_2 emissions!

Discussion: Austria vs. Canada

A current study (Knowles et al., 2023) allows us to compare snowmaking in Austria and Canada.

AUSTRIA (AUT)

Skier Visits per Year

- ✓ 49.5 million Season 2022/23 (Vanat, 2024)

Water demand for snowmaking

- ✓ 43.8 million m³

Energy consumption (snowmaking)

- ✓ 281 GWh

CO_2 emissions (snowmaking)

- ✓ 2,831 tons
- ✓ 54 g per skier visit
  226 kg / ha

CANADA (CAN)

Skier Visits per Year

- ✓ 21.1 million Season 2022/23 (Vanat, 2024)

Water demand for snowmaking

- ✓ 43.4 million m³ (Knowles et al., 2023)

Energy consumption (snowmaking)

- ✓ 478 GWh (Knowles et al., 2023)

CO_2 emissions (snowmaking)

- ✓ 130,095 tons (Knowles et al., 2023)
- ✓ 6.2 kg per skier visit

→ In CAN, the CO_2 footprint of snowmaking – adjusted for skier visits – is more than 100 times higher!
Reasons for this may include: A “greener” mix of electricity in Austria and more efficient snowmaking systems.

Discussion: Water

The average annual precipitation in Austria is 1136 mm (Chimani et al. 2016).
With an area of 83,878 km² (Bundesministerium für Arbeit und Wirtschaft 2024), there is an annual rainfall of 95,285,408,000 m³.

Water requirement for snowmaking	**Annual rainfall AUT**
43.4 million m³	**95.3 billion m³**

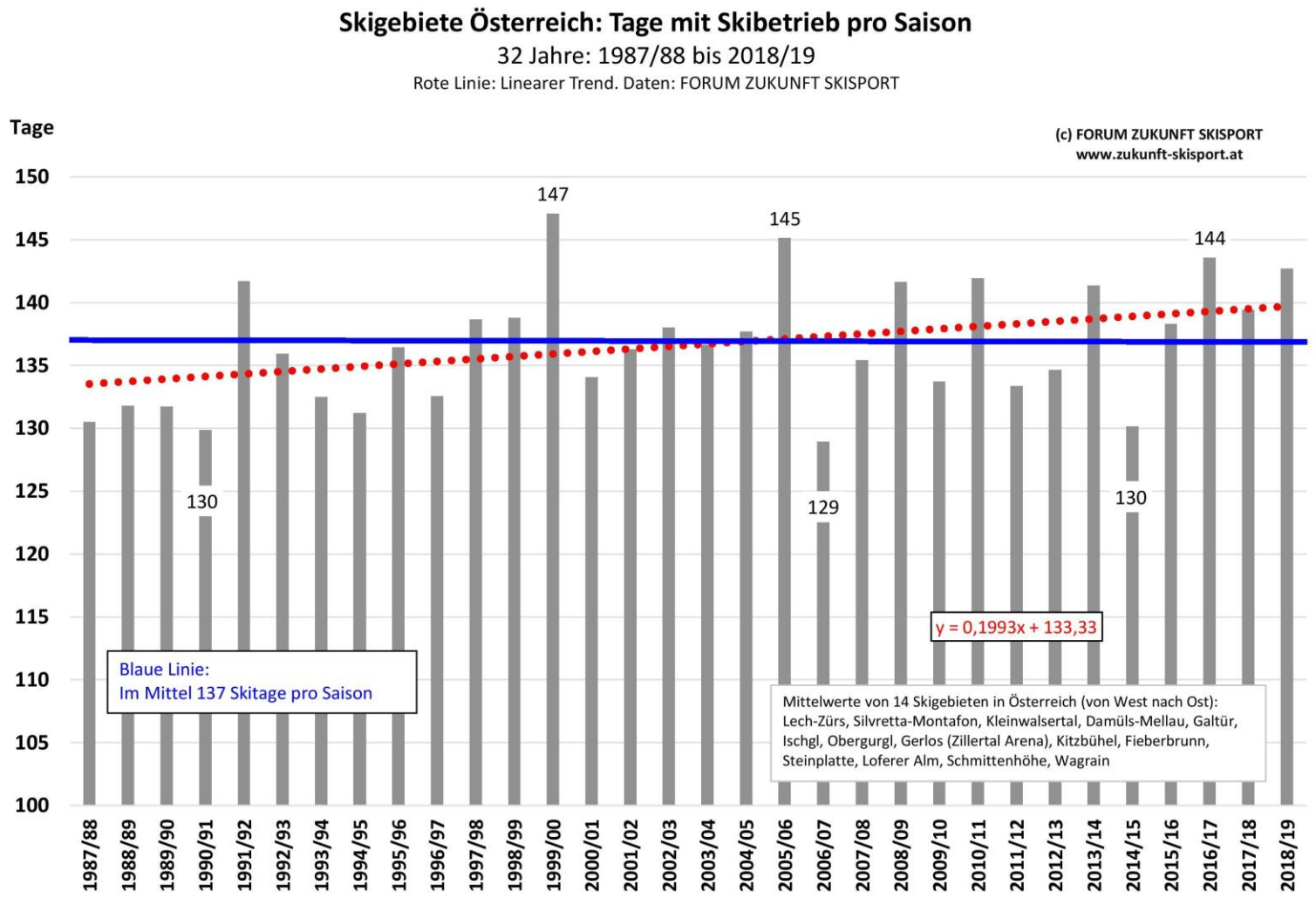
The water requirement is 0.046 % of the annual precipitation

→ In Austria, 4.6 ten thousandths of the annual precipitation is used for snowmaking.
For every liter of precipitation, less than 5% of the volume of a thimble is used for snowmaking.

→ **After the snow melts, this water returns to the natural water cycle completely, unchanged and drinkable.**

→ **The water requirement for snowmaking is a prime example of a functioning circular economy.**

Ski Season Lengths



This graph shows the development of ski season lengths in 14 Austrian ski areas from 1987/88 to 2018/19 (pre-covid).

Snowmaking has made it possible for the length of the ski seasons to be emancipated from meteorological developments.

Conclusions for Ski Tourism

- ✓ The consumption data for snowmaking in Austria assumed in the literature appear to be too high. Both the public and scientific debate about snowmaking need an updated discussion which includes concrete data.
- ✓ On the way to climate-neutral ski resorts, snowmaking is only a small hurdle compared to diesel-powered slope preparation and guests' travel to and from the ski resorts.
- ✓ From a business perspective, an increased use of snow lances could be examined in order to reduce the energy consumption of snowmaking.

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