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

Günther

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

- 28 ski areas achieved a data quality that meets the requirements of this study
- Data from 7 Austrian states (out of 9)
- Sample total: **3,921 hectares equipped with snowmakers**
- Sample total: **16.3 million skier visits** … which corresponds to a share of 31.1 percent of the Austrian skier visits (WKO 2023a)
- Mean sea level (of all mountain and valley stations): 1,433 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)
    - 5 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: 6.32 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)

→ 43.4 million m³

Total annual energy demand for technical snowmaking in Austria

→ Extrapolation per skier visits (52.5 million)

→ 273 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

→ 2,751 tonnes

Results – Key Figures

Total number of snowmakers:	**35,735**
Ratio of fan guns to lances: 48.6 to 51.4 %.	17,388 fan guns and 18,347 lances
Number of snowmakers per ha:	2.8
Number of snowmakers per 1,000 Skier Visits:	0.7
Average operating time:	**171 h**
Km of slopes equipped with snowmakers, % of total km:	**81.7 %**
Snow production from green energy:	**99.9 %**
Water per ha:	**3,436 m³**
Energy per ha:	**21,597 kWh**
Energy per 1 m³ snow	**3.5 kWh**
Energy per Skier Visit	**5.2 kWh**
CO_2 per Skier Visit	**52 g**

= equal to 0.4 km driven with a gasoline powered car

Discussion: Electricity and CO_2

Power consumption

Snowmaking	Snowmaking, cable cars and lifts
➢ **273 GWh**	Approx. **819 GWh**
➢ = 0.43 %	= 1.29 %

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

CO_2 emissions

Snowmaking	Snowmaking, cable cars and lifts
➢ **2,751 t**	Approx. **8,253 t**
➢ = 0.0038 %	= 0.0113 %

… 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 CO2-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

✓ 43.4 million m³

Energy consumption (snowmaking)

✓ 273 GWh

CO_2 emissions (snowmaking)

✓ 2,751 tons

✓ 56 g per skier visit

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

43.4 million m³

Annual rainfall AUT

95.3 billion m³

The water requirement is 0.046 % of the annual precipitation

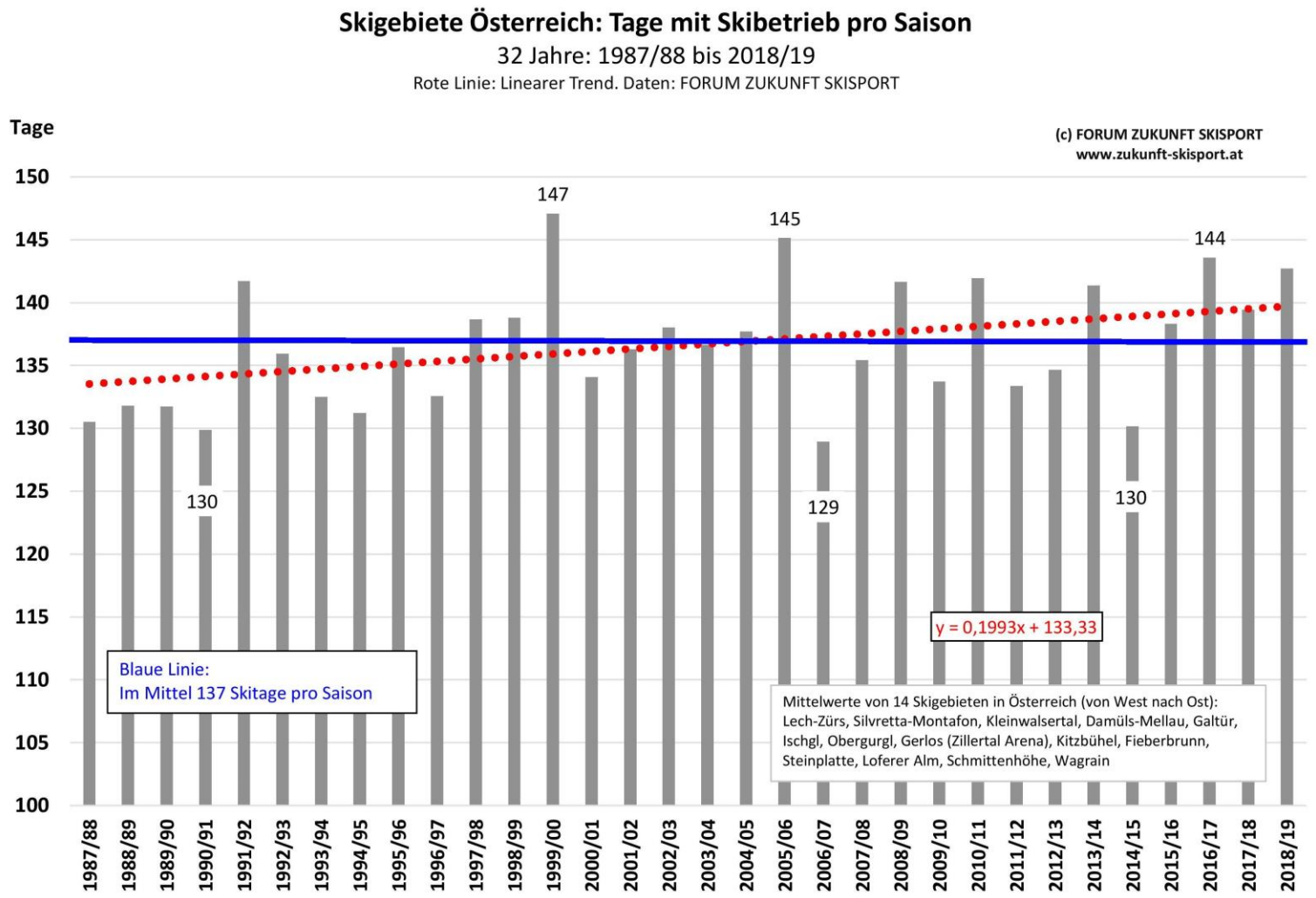
→ In Austria, 4.6 ten thousandths of the annual precipitation is used for snowmaking.

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 an 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.
- ✓ Snowmaking seems to be more sustainable and greener than expected.
- ✓ Snowmaking only makes a negligible contribution to increasing the CO_2 concentration in the atmosphere. It is not an example of a maladaptation.
- ✓ Prejudices against snowmaking need to be broken down: with transparent, fact-based information. Due to the lack of empirical data, the discussions of the past decades seem to have been based on emotions and assumptions.
- ✓ **Both the public and scientific debate about snowmaking need an updated discussion which includes concrete data.**

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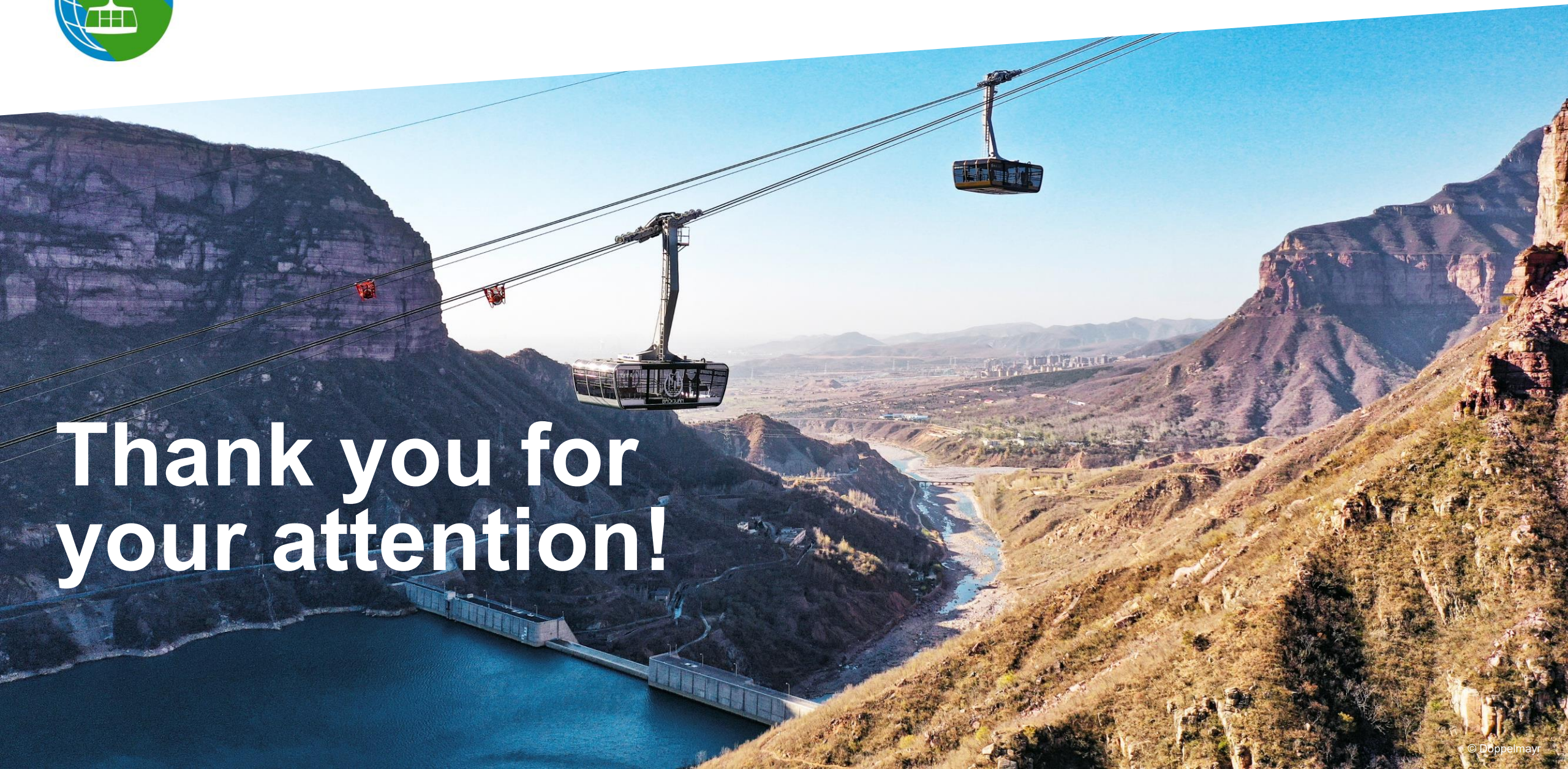
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