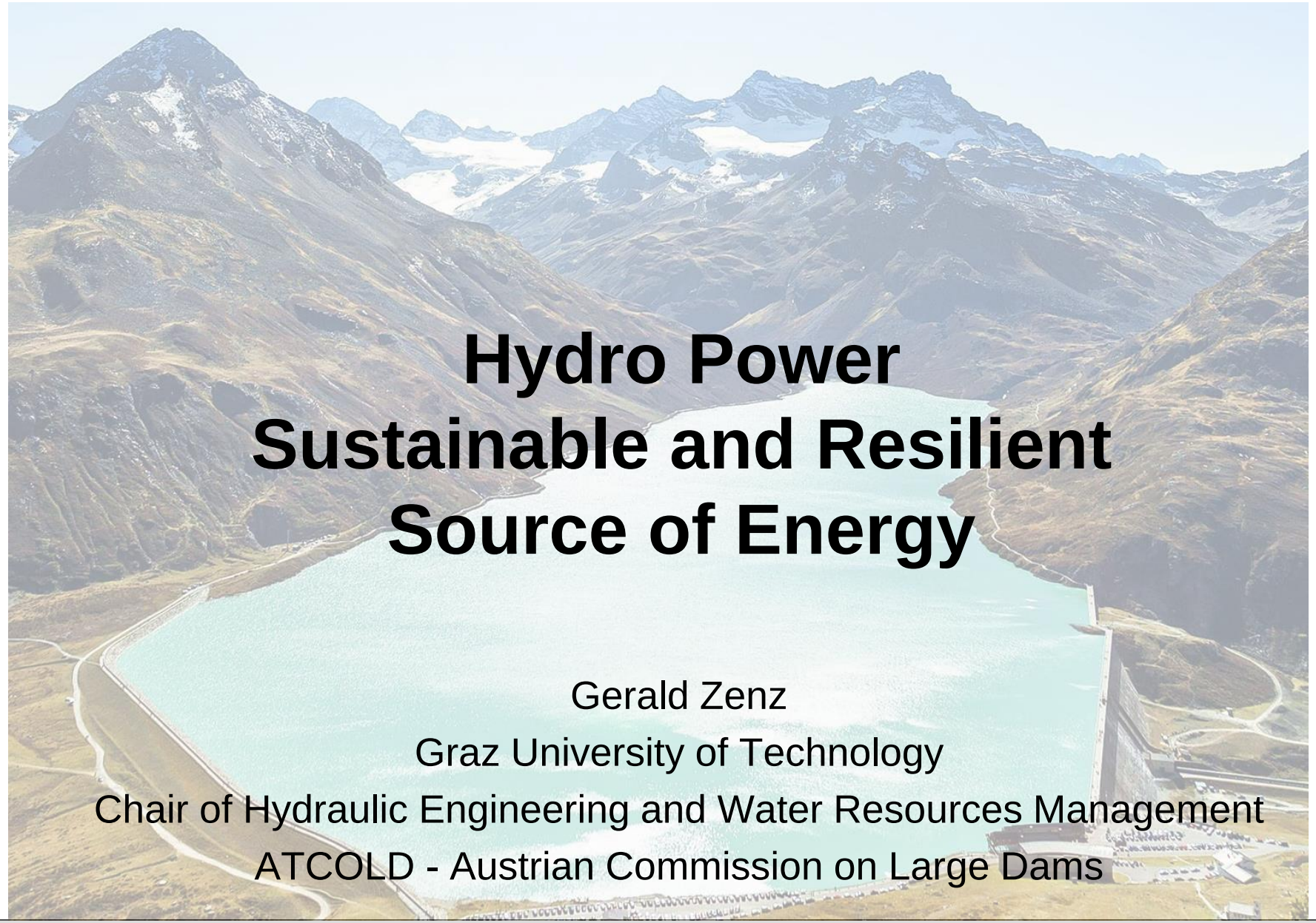

Hydro Power
Sustainable and Resilient
Source of Energy

Gerald Zenz
Graz University of Technology
Chair of Hydraulic Engineering and Water Resources Management
ATCOLD - Austrian Commission on Large Dams

Hydro Power – Sustainable and Resilient Energy Source

General View of Hydro Utilization Worldwide

- Role of reservoirs - irrigation, energy, multi-purpose
- Provision for local, sustainable and resilient energy

Main Challenges – Energy from Renewable Sources

- Technical Issues
- Commercial Aspects

Hydro Power in the Energy Transition Process

- Volatile renewables - photovoltaic and wind
- Way in Europe, alpine region and Austria
- Multiple role of reservoirs and run of river plants

Hydro Power Developments

- Rehabilitation Work and development in progress
- Examples of actual projects

Hydro Power – Sustainable and Resilient Energy Source

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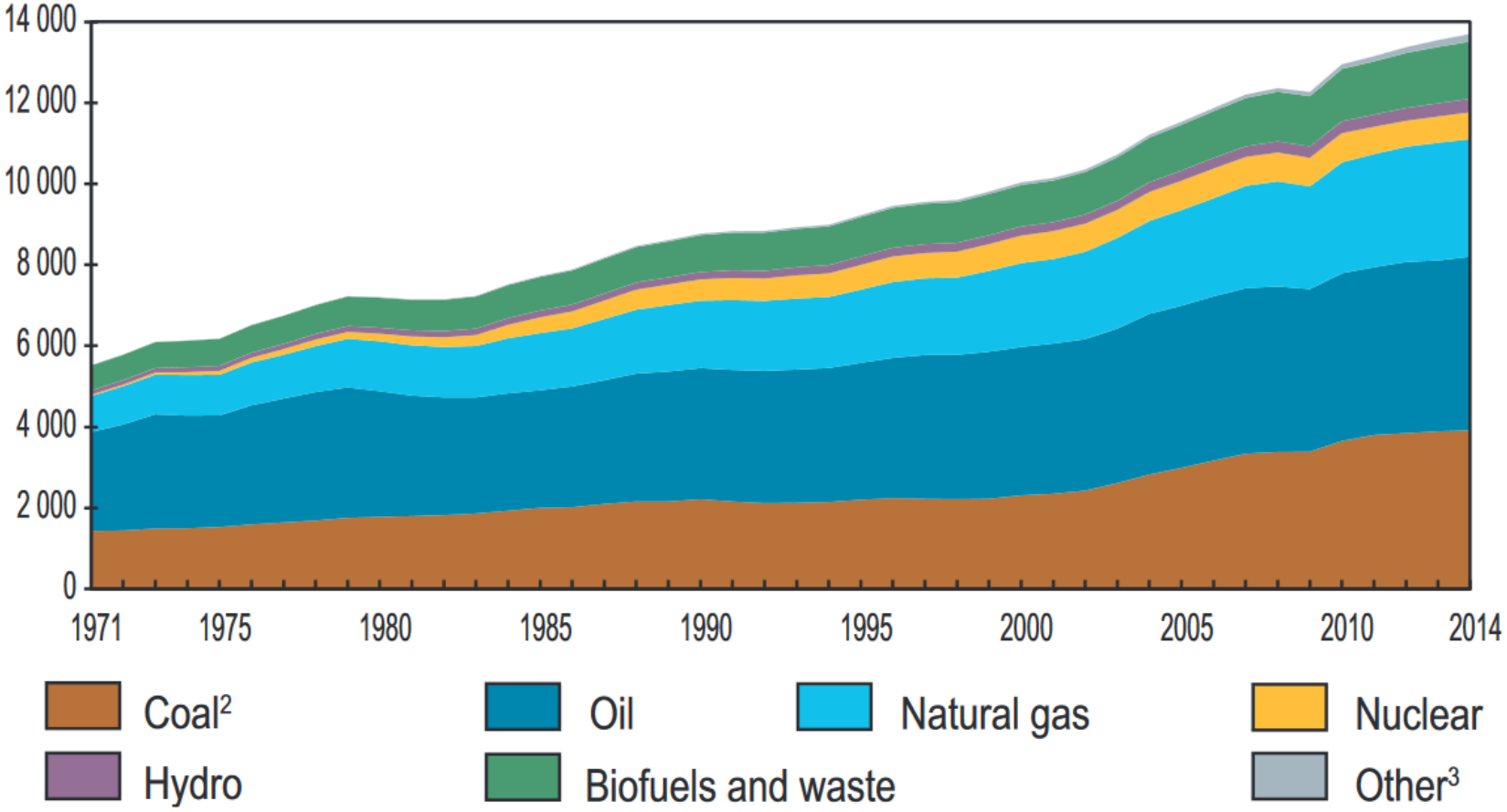
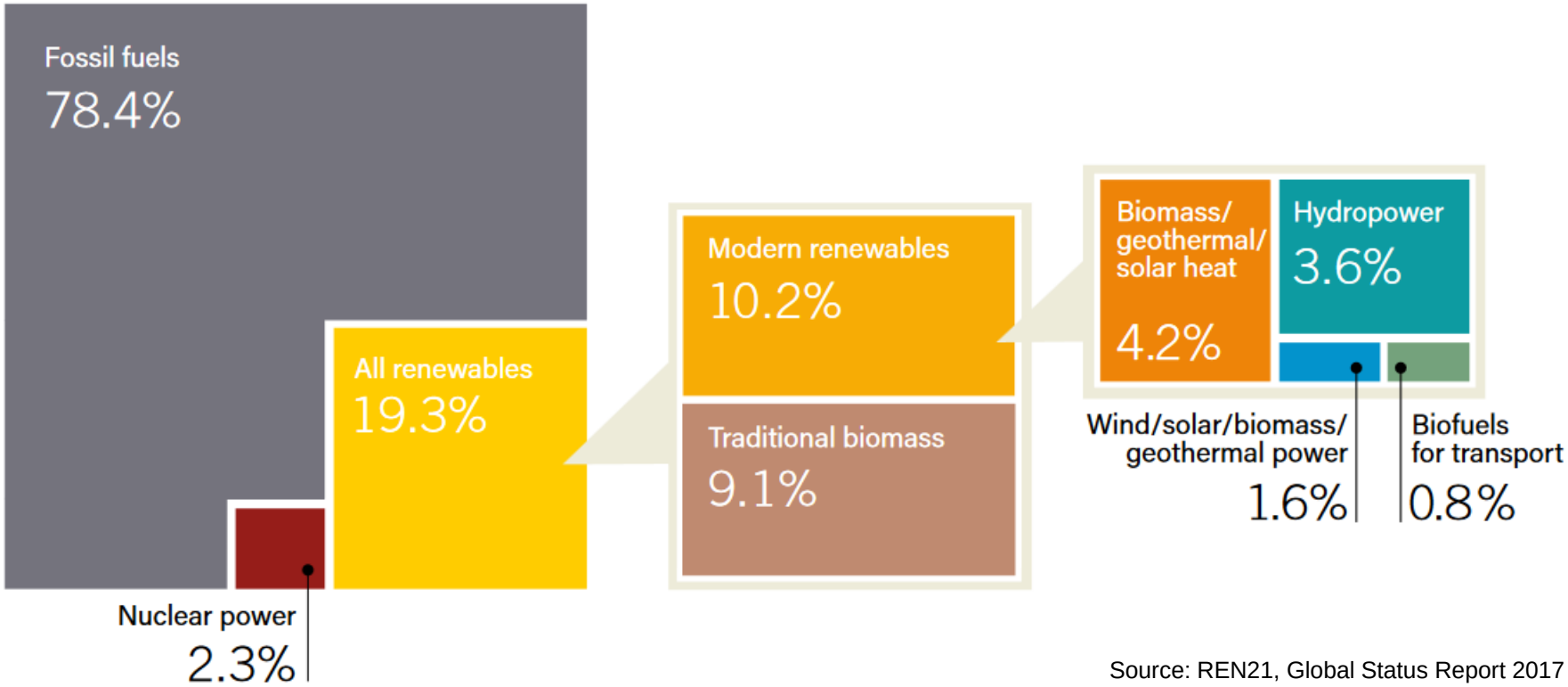
Hydro Power Developments
- Rehabilitation Work and development in progress
- Examples of actual projects

Worldwide - Share of Fossil Fuels

(in Mtoe ~ 11,6TWh)



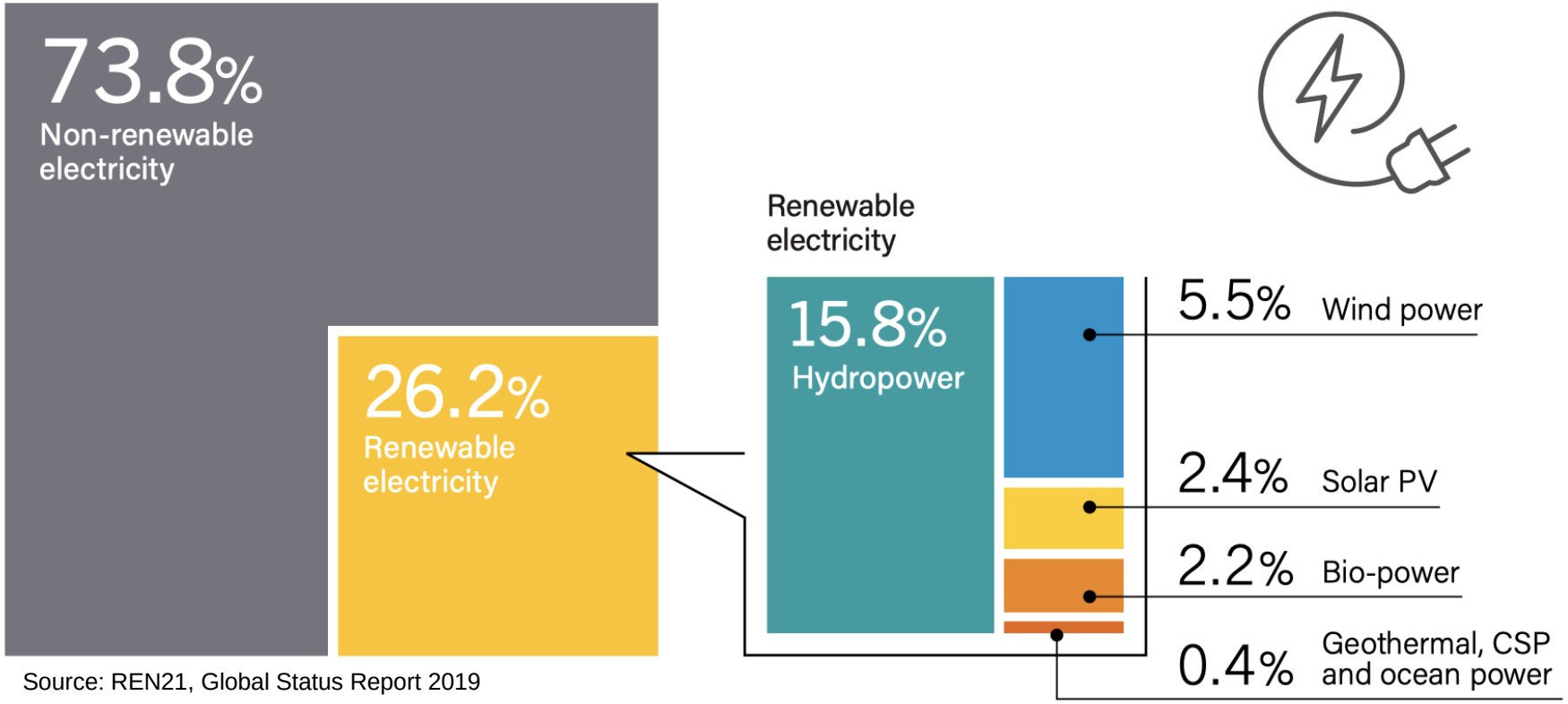
Global Energy Consumption – Part of REN



Source: REN21, Global Status Report 2017

Energy – 80% Fossile Fules – 20% Energy from Renewable Sources

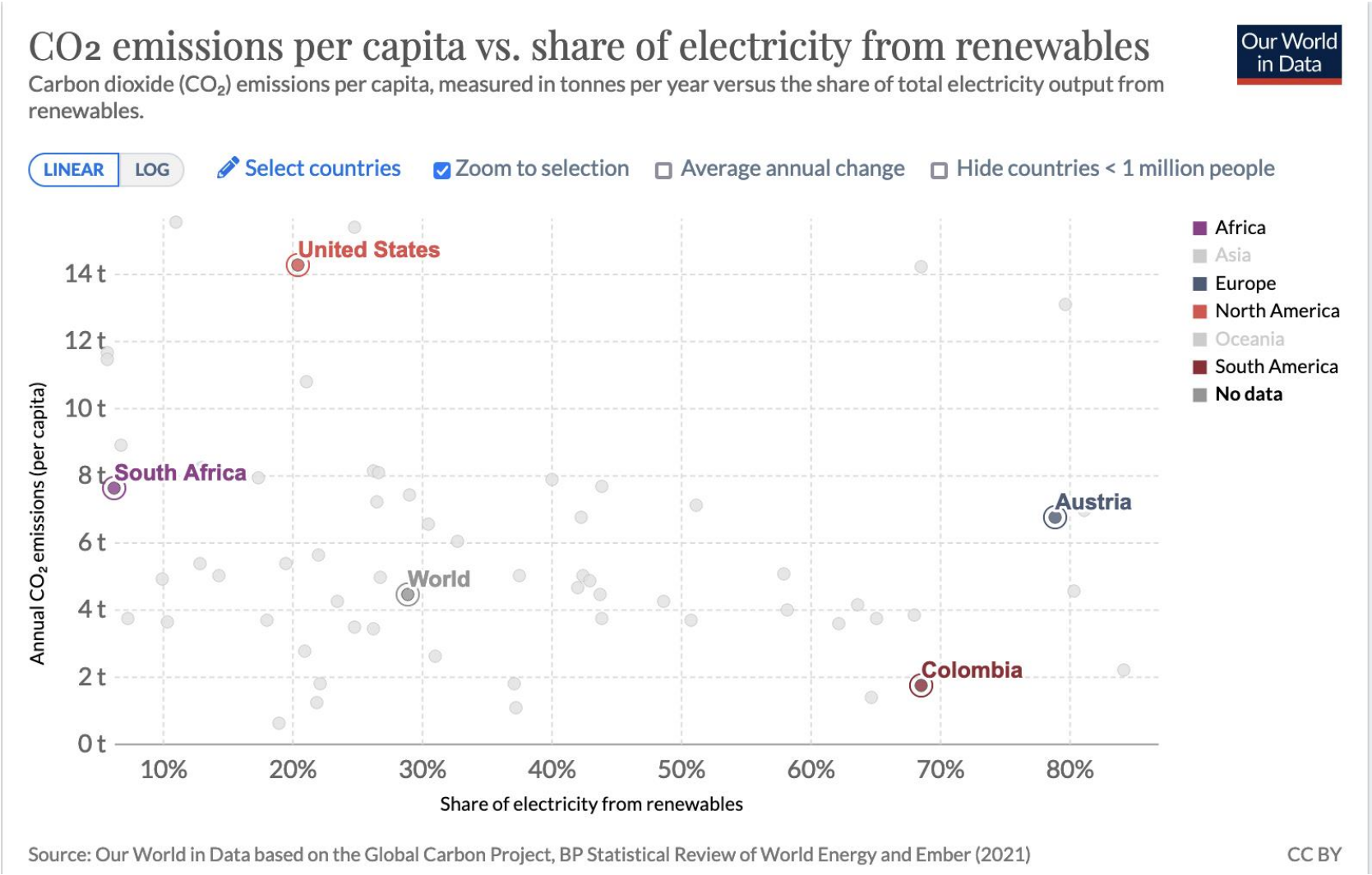
Electricity - Renewable Sources



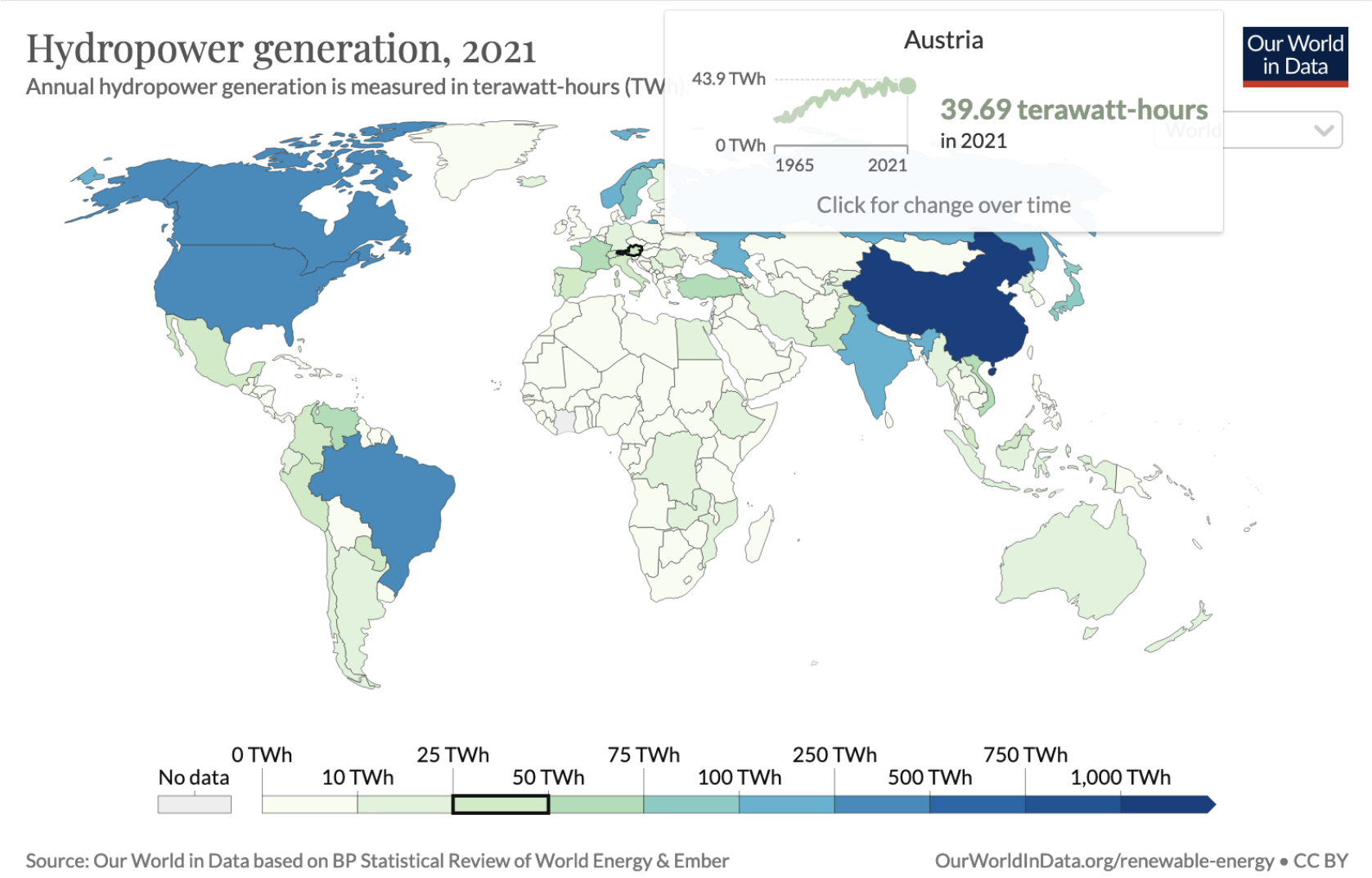
Source: REN21, Global Status Report 2019

74% Non Renewable - 26% Renewable Sources

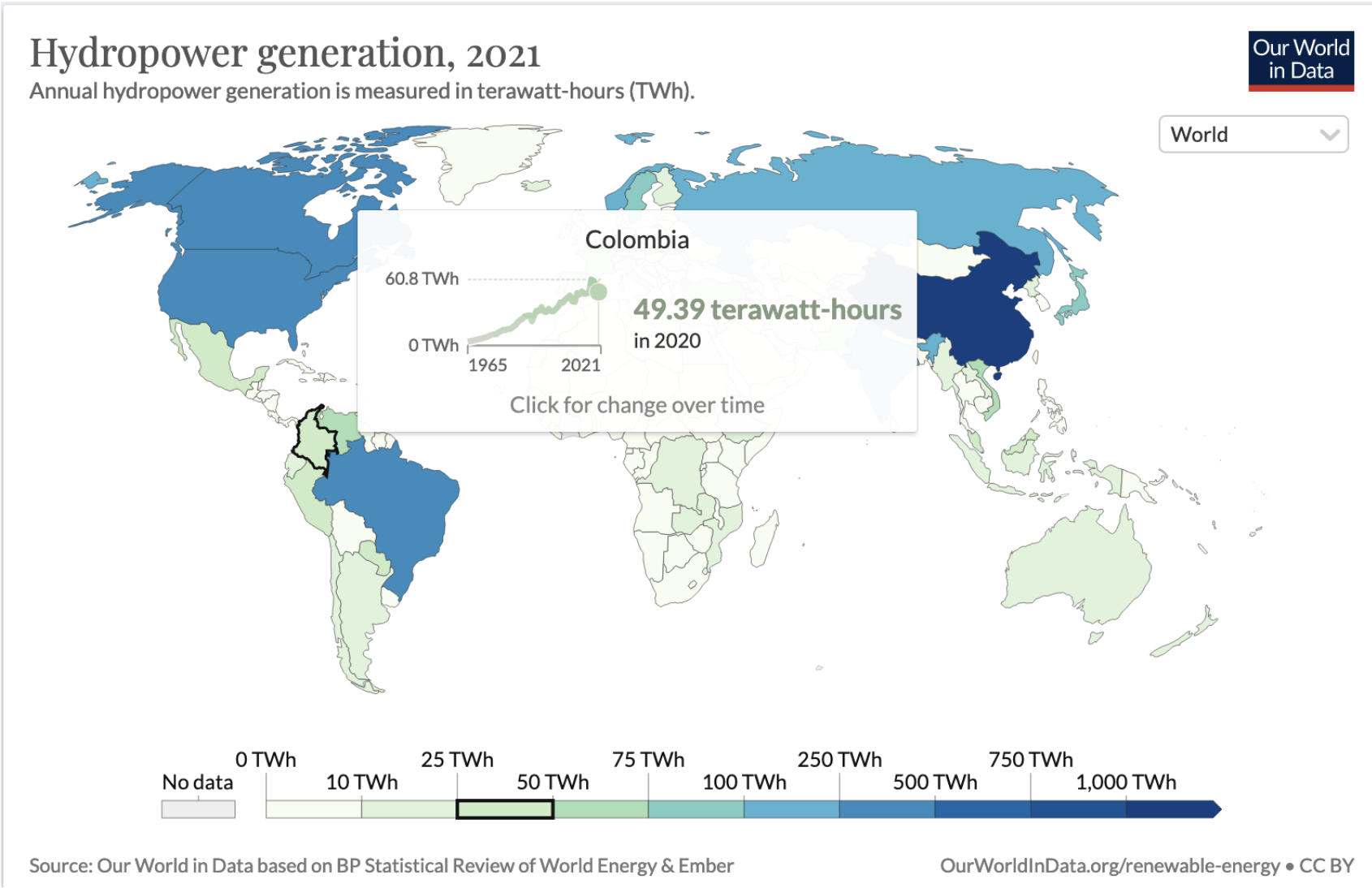
Carbon – Versus Electricity from Renewables



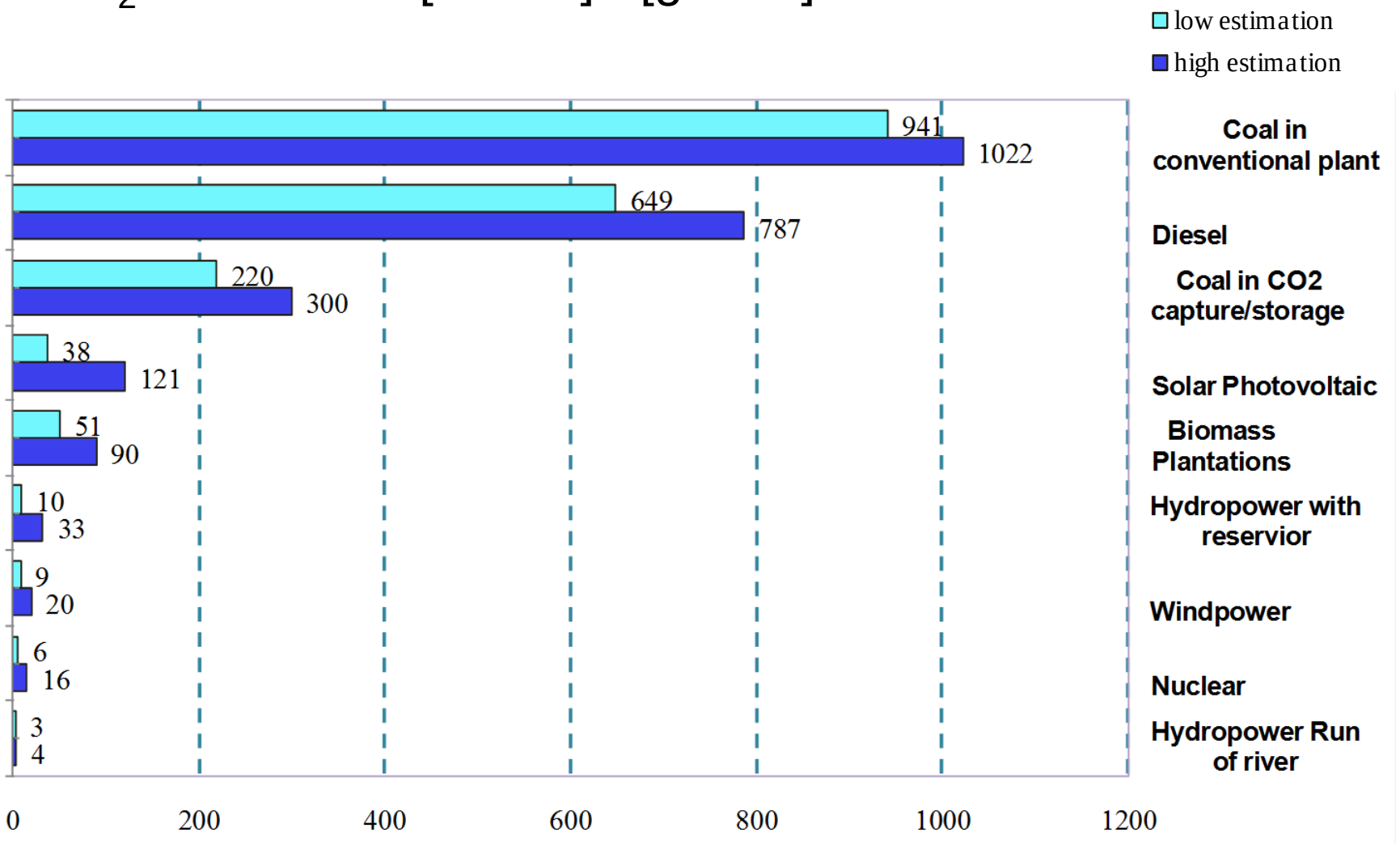
Development of Hydropower



Development of Hydropower



Electricity - CO_2 Emission – [t/GWh] - [g/kWh]

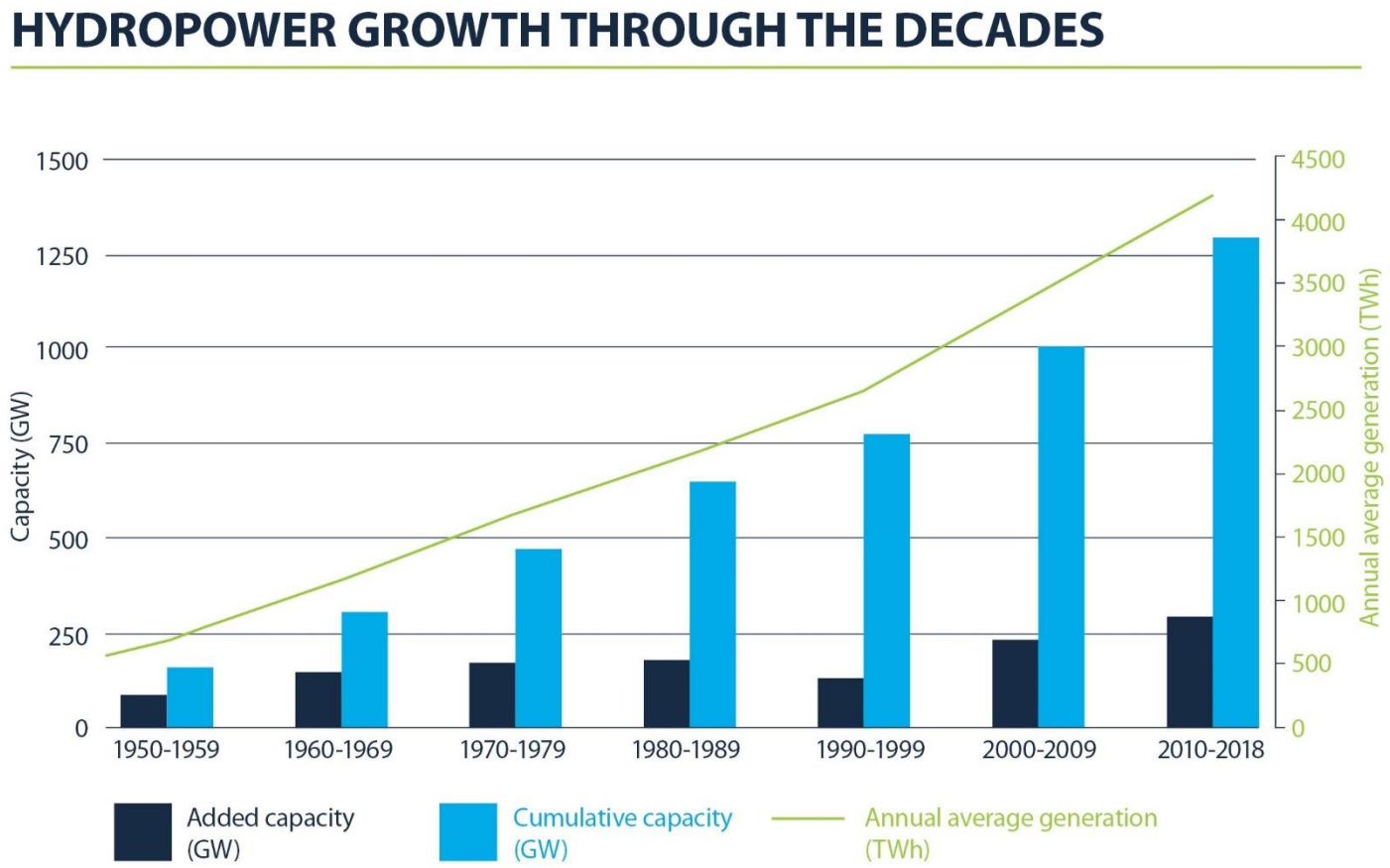


Source: Hydro Quebec; CHINCOLD – J. Jia

Hydro Power – Worldwide Leading Renewable Energy Source

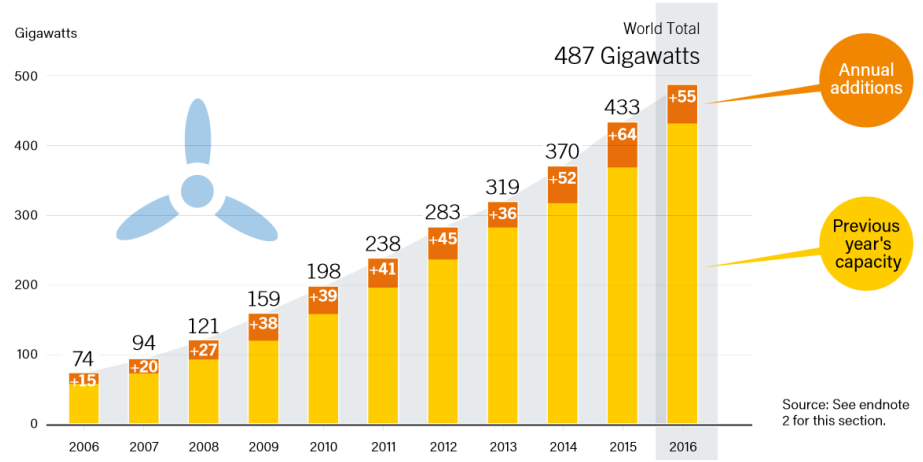
- Reliable
- Inexpensive Fuel
- Zero emission
- Renewable supply of electrical energy
- Provision of services for electrical energy system
  - Storage in all time ranges
  - System flexibility, stabilization and security of supply
  - Frequency stability, grid restoration
- Water services
  - Avalanche and flood protection
  - Improvement of traffic infrastructure
- Service life – more than 100years
- Rehabilitation to improve efficiency and ecology

Hydropower – System Energy Transformation



Worldwide Increase of Contribution

Sustainable Hydro - Renewable - PV – Wind - Hydro

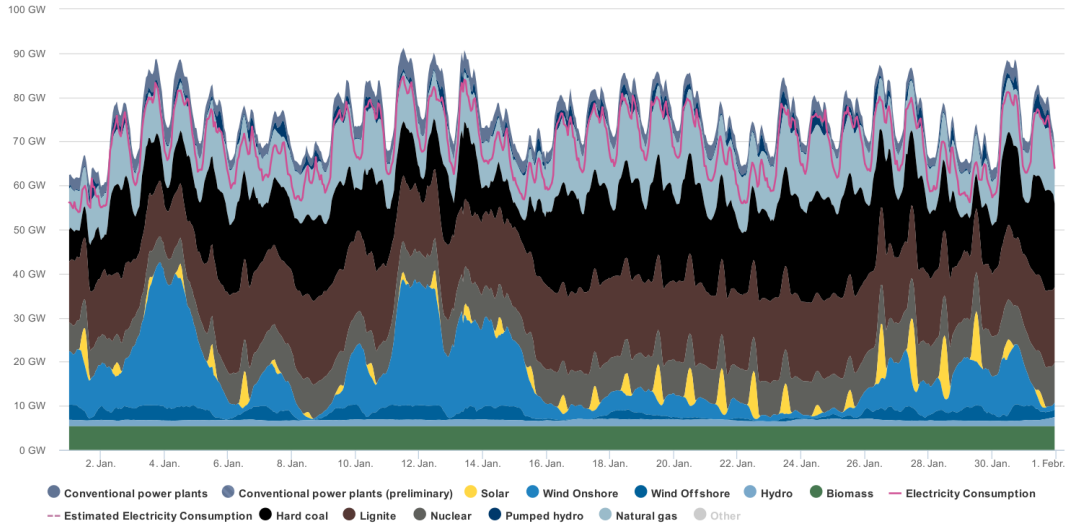


Electricity Production / Consumption, **GermanyJan 2017**

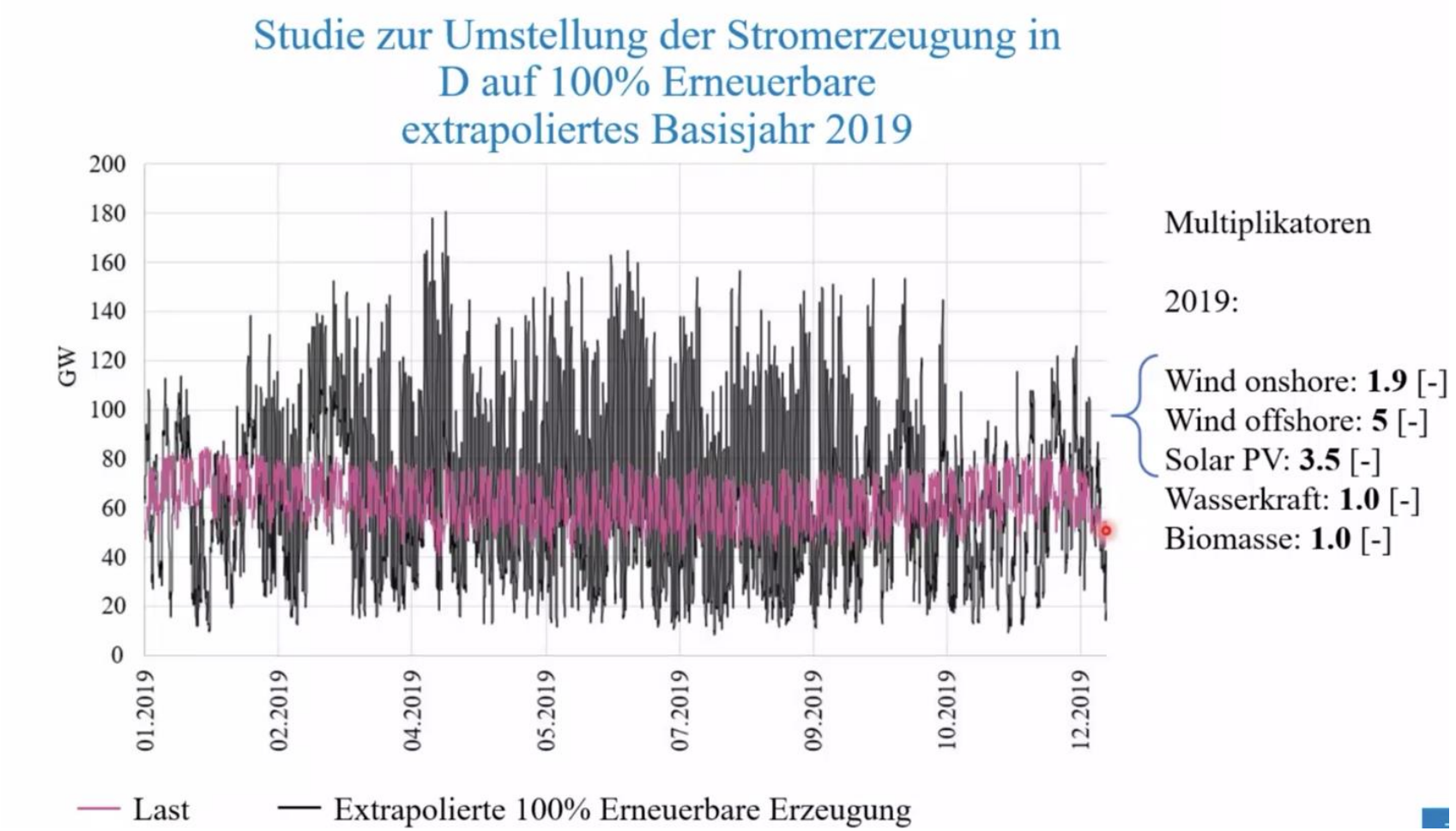
High Volatility
Flexibility

Storage Capacity
Pumped Hydro Plants

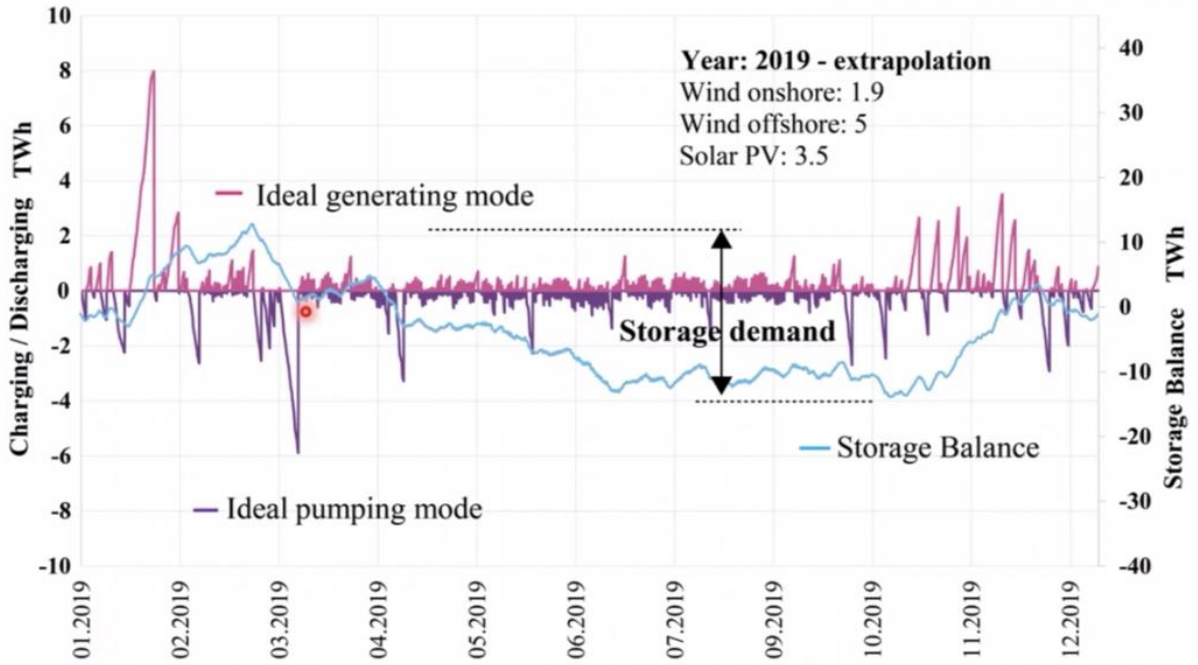
Growing Energy Demand



Simulation – 100% Volatile Electricity from Renewables



Study - Ideally Required Storage - Germany



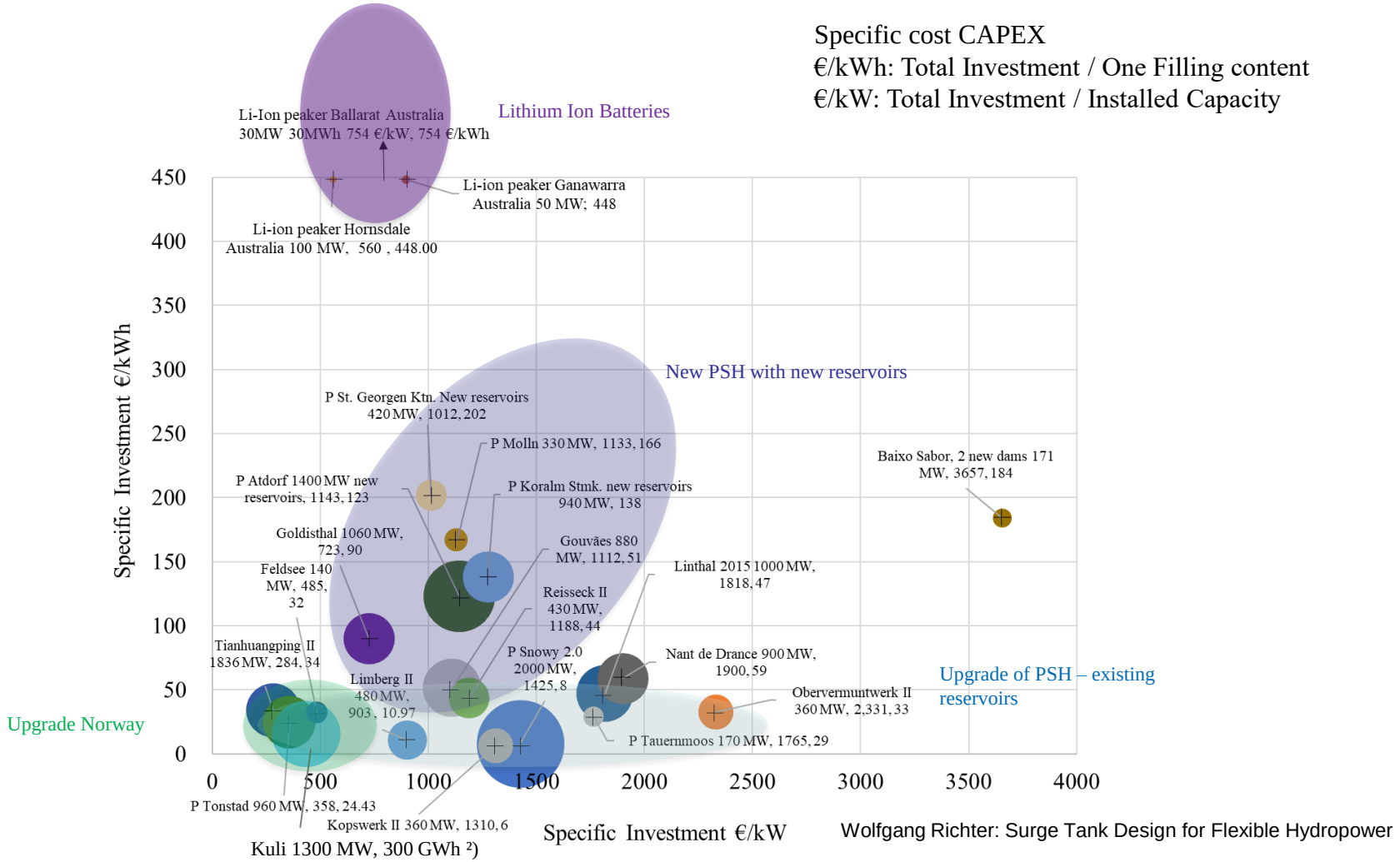
Storage about ”only” **5% of total annual energy** demand

In 2019 gross power consumption – approx. 550TWh

Richter et. al.: Economic and sustainable energy transition enabled by pumped-storage hydropower plants [Hydro 2020]

Comparison - Efficient, economical, sustainable

Specific cost CAPEX
€/kWh: Total Investment / One Filling content
€/kW: Total Investment / Installed Capacity



Wolfgang Richter: Surge Tank Design for Flexible Hydropower

Contribution - Hydro Alpine Region – Entire EU-28

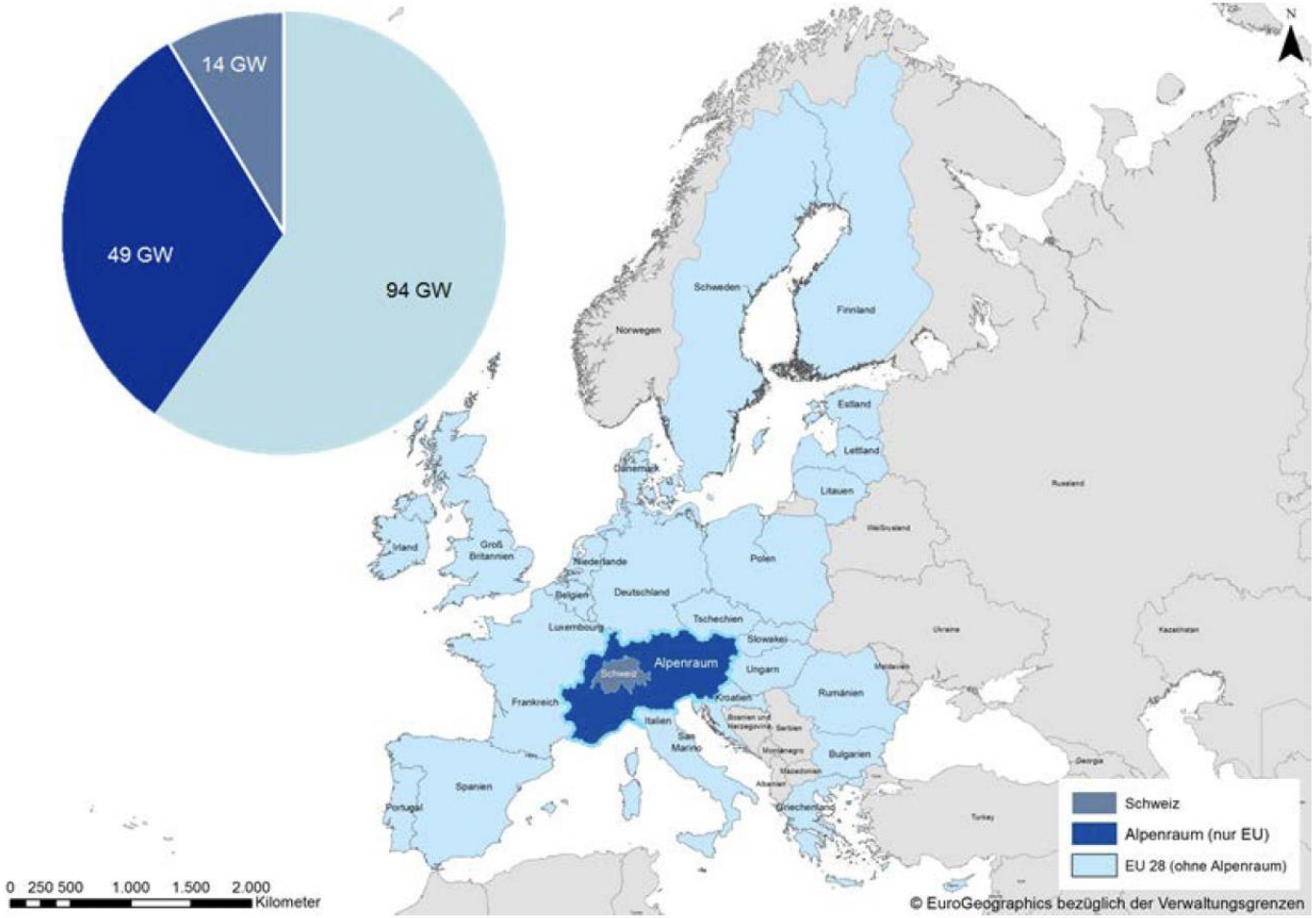


Abbildung 5-25: Wasserkraftleistung der EU im Vergleich zum Alpenraum (in GW)

Alpine Region – Reservoir HPP and Pumping Capacity

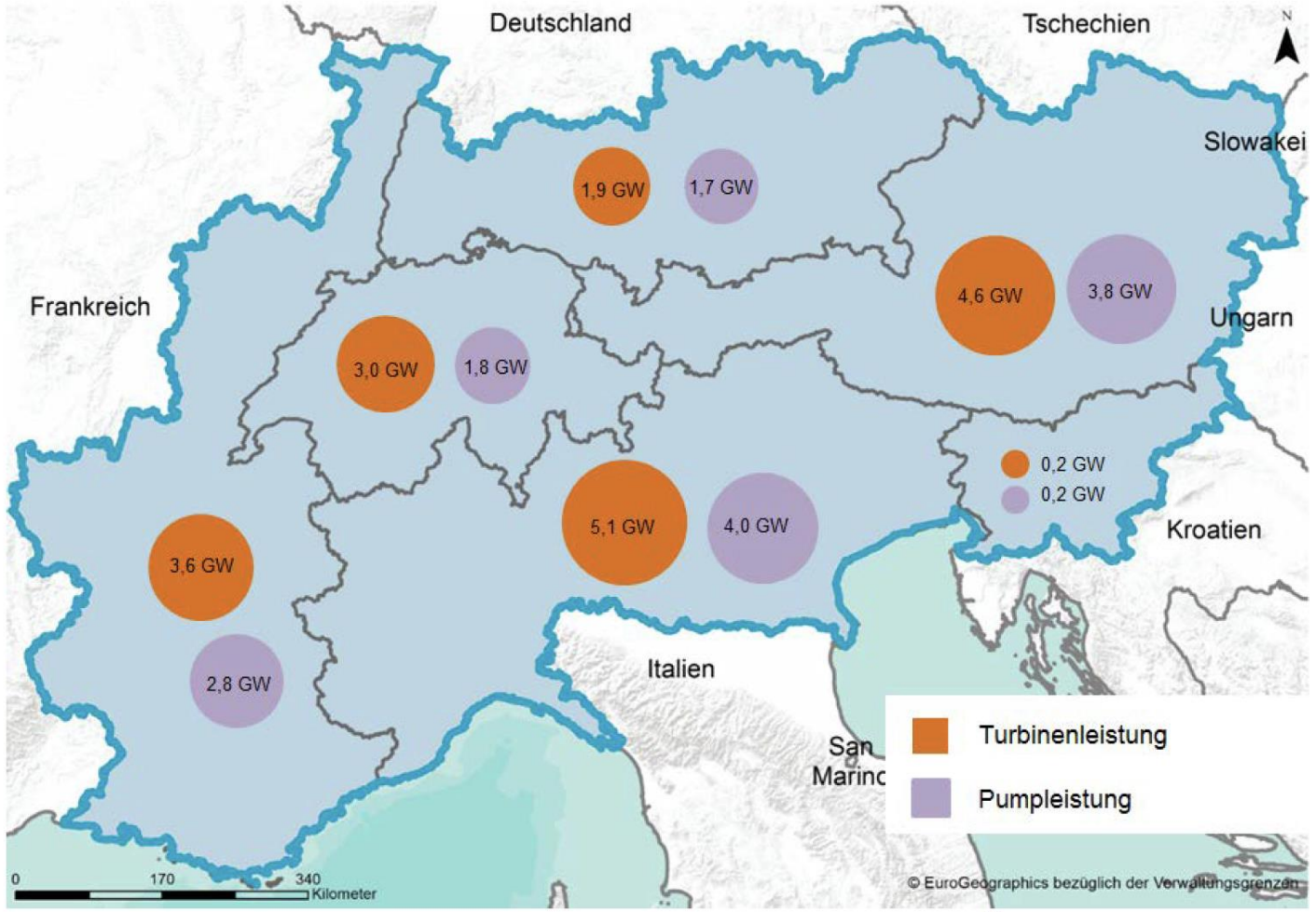


Abbildung 5-16: Turbinen- und Pumpleistung der Pumpspeicherkraftwerke[11]

Alpine Region – Comparison - Norway & Sweden [GW]

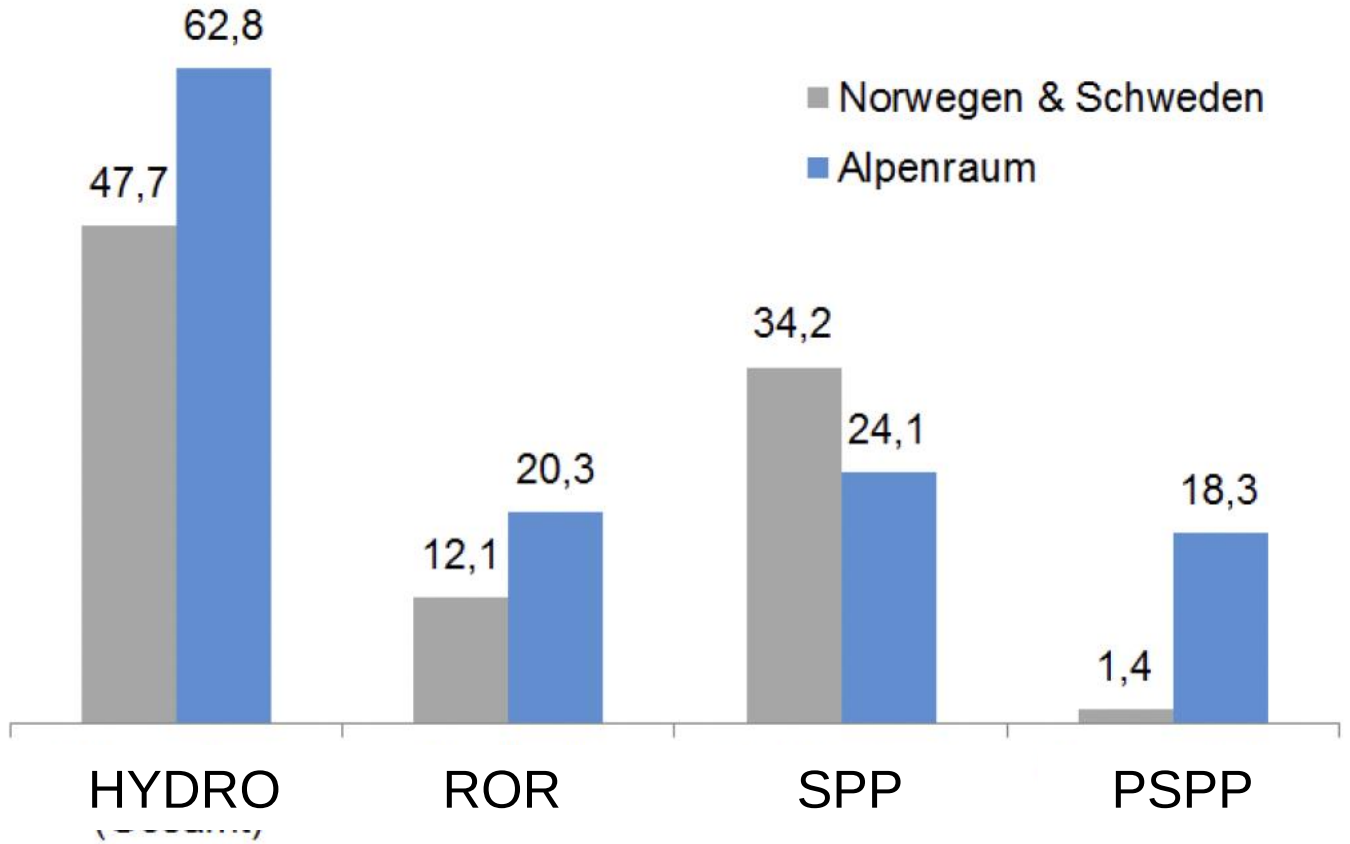


Abbildung 5-27: Wasserkraftleistung (N, SWE) im Vergleich zum Alpenraum (GW)[18]

Alpine Region – Comparison - Norway & Sweden

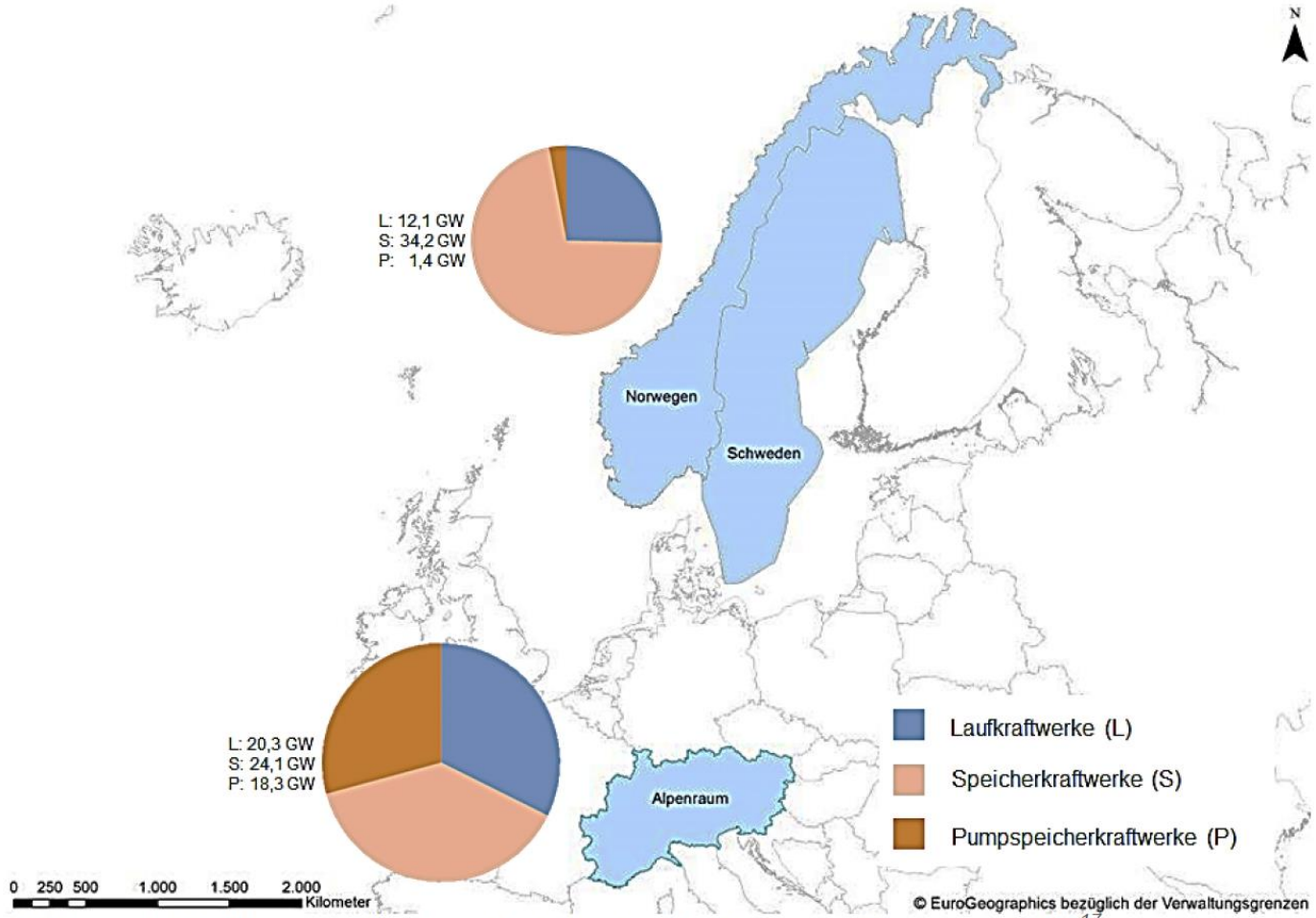
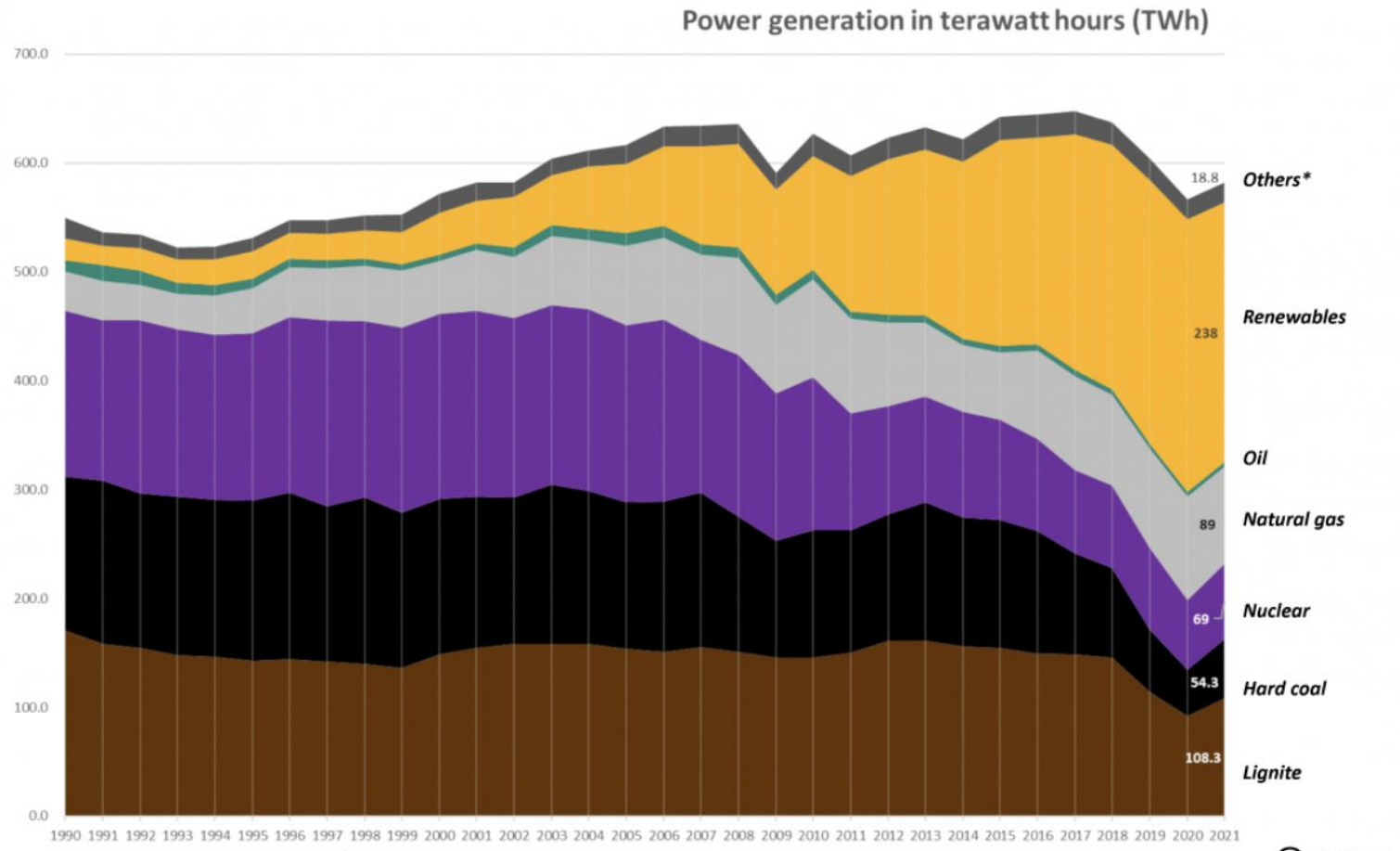


Abbildung 5-26: Wasserkraftleistung (N, SWE) im Vergleich zum Alpenraum (GW)[17]

Gross power production in Germany 1990 - 2021, by source.

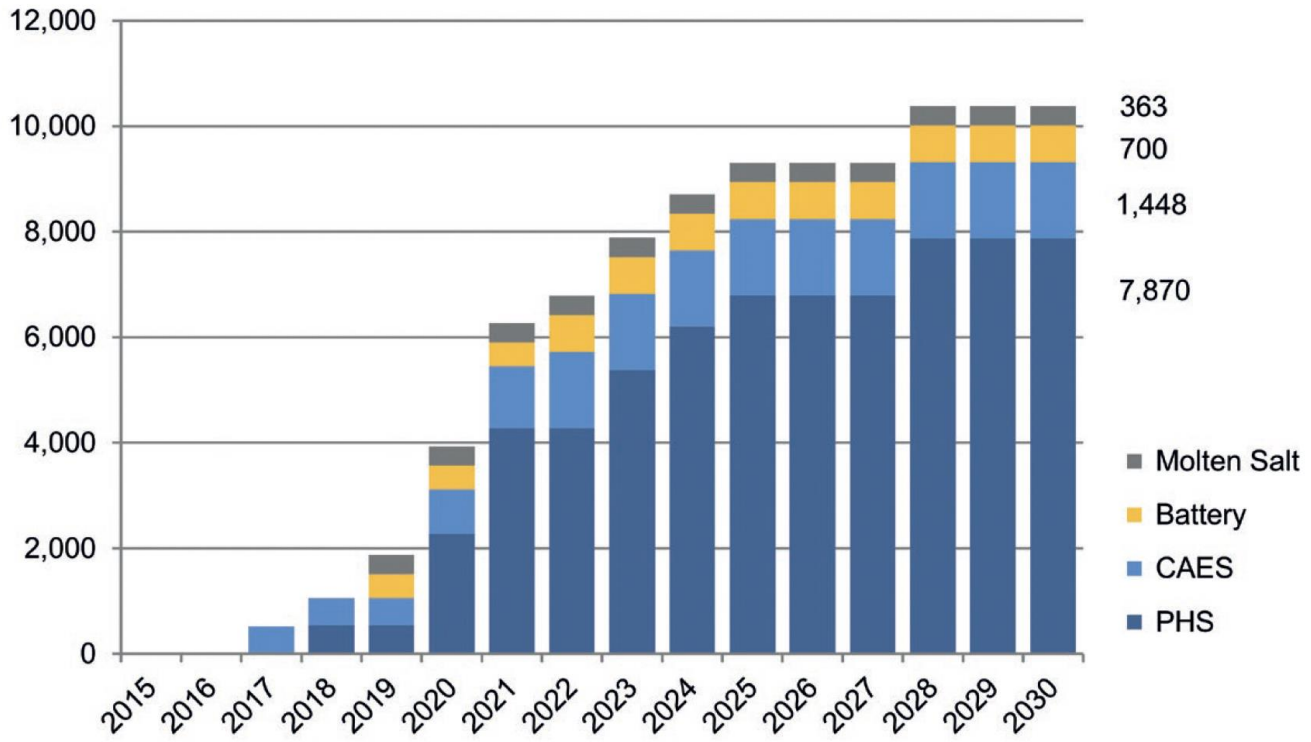
Data: BDEW 2021, data preliminary.

CLEAN ENERGY WIRE



* Without power generation from pumped storage.

2030 – Additional Storage Capacity - EU



Capacity with cross-border relevance

Projects of Common Interest

Ref.: ENTSO-E TYNDP 2016 Storage fact sheet

- Batteries, demand side management
- Smart solutions, compressed air
- Power to Gas to Power not justifiable
  - P2G – G2P results in only approx. 25% of efficiency

What we are already proud of - Future

Dams Serve for a better world

Pic.: Verbund

Kaprun – Limberg / Mooserboden

Pic.: Verbund

Hydro Power
Flood Protection
Drinking Water
Irrigation

Safety Concept
Structural
Monitoring
Operation

Risk Assessment
Structural Safety
Risk Management
Education

Climate Change - Flood Protection due to Reservoirs

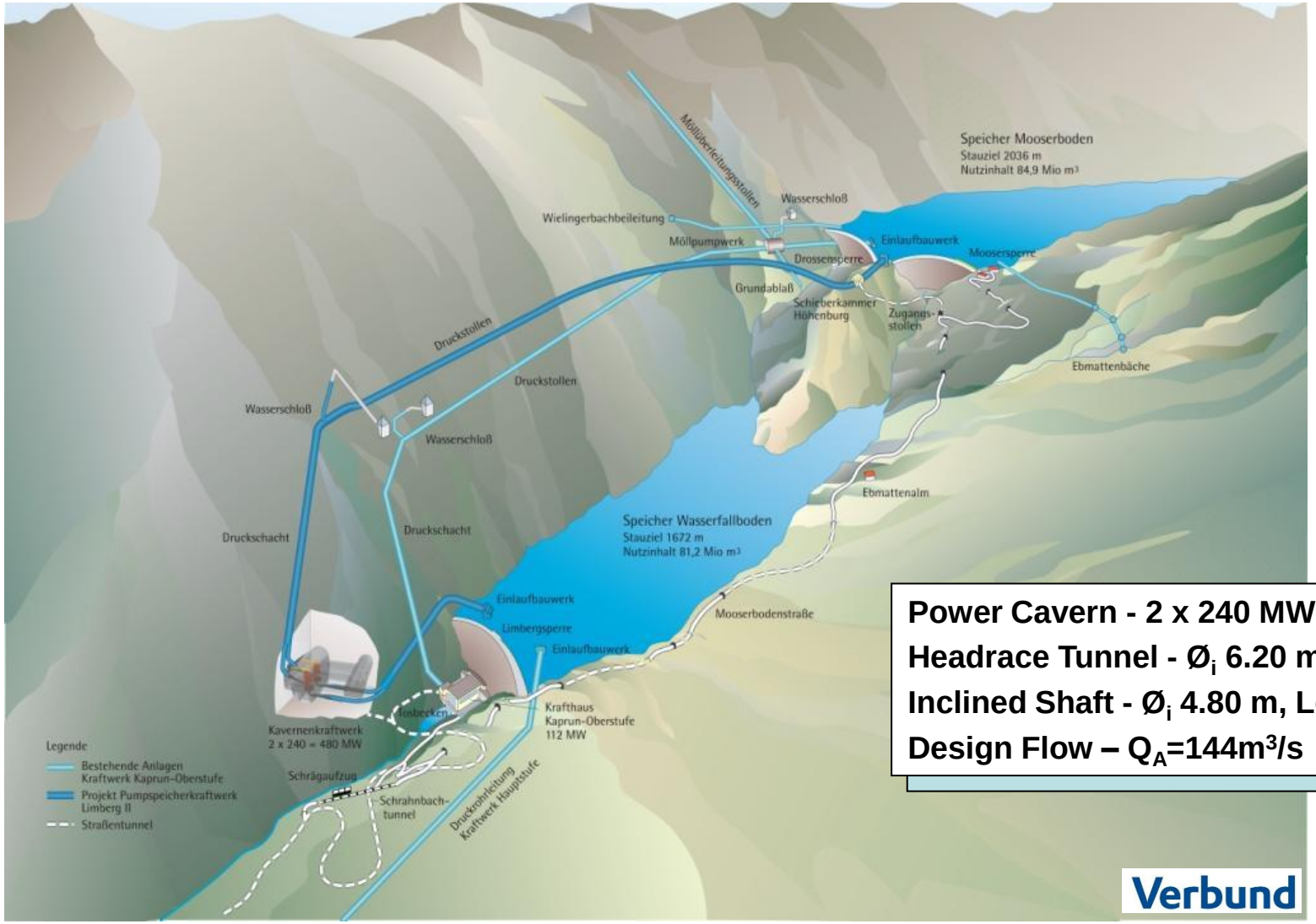
Essential Contribution to flood protection and retention

Run-of-River Plants

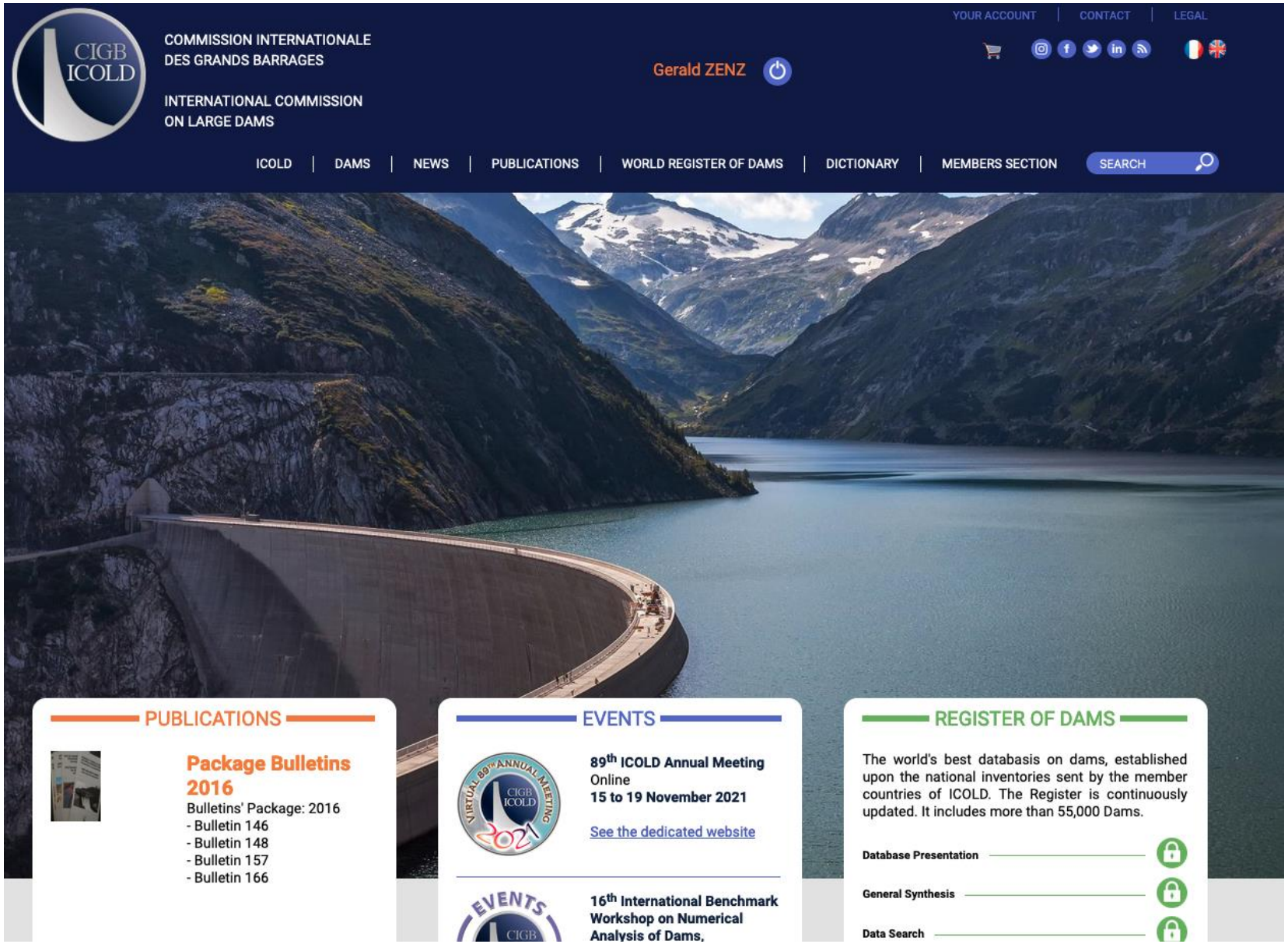
Reservoir Power Plants

Run Off – Retention and Retention Reservoirs

Pumped Storage Scheme – Kaprun



Power Cavern - 2 x 240 MW
Headrace Tunnel - Ø$_i$ 6.20 m, Lg. 4km
Inclined Shaft - Ø$_i$ 4.80 m, Lg. 0.6 km
Design Flow – Q_A=144m³/s


CIGB ICOLD
COMMISSION INTERNATIONALE DES GRANDS BARRAGES
INTERNATIONAL COMMISSION ON LARGE DAMS
Gerald ZENZ
YOUR ACCOUNT | CONTACT | LEGAL
ICOLD | DAMS | NEWS | PUBLICATIONS | WORLD REGISTER OF DAMS | DICTIONARY | MEMBERS SECTION
SEARCH
PUBLICATIONS
Package Bulletins 2016
Bulletins' Package: 2016
- Bulletin 146
- Bulletin 148
- Bulletin 157
- Bulletin 166
EVENTS
89th ICOLD Annual Meeting
Online
15 to 19 November 2021
See the dedicated website
16th International Benchmark Workshop on Numerical Analysis of Dams,
REGISTER OF DAMS
The world's best databasis on dams, established upon the national inventories sent by the member countries of ICOLD. The Register is continuously updated. It includes more than 55,000 Dams.
Database Presentation
General Synthesis
Data Search

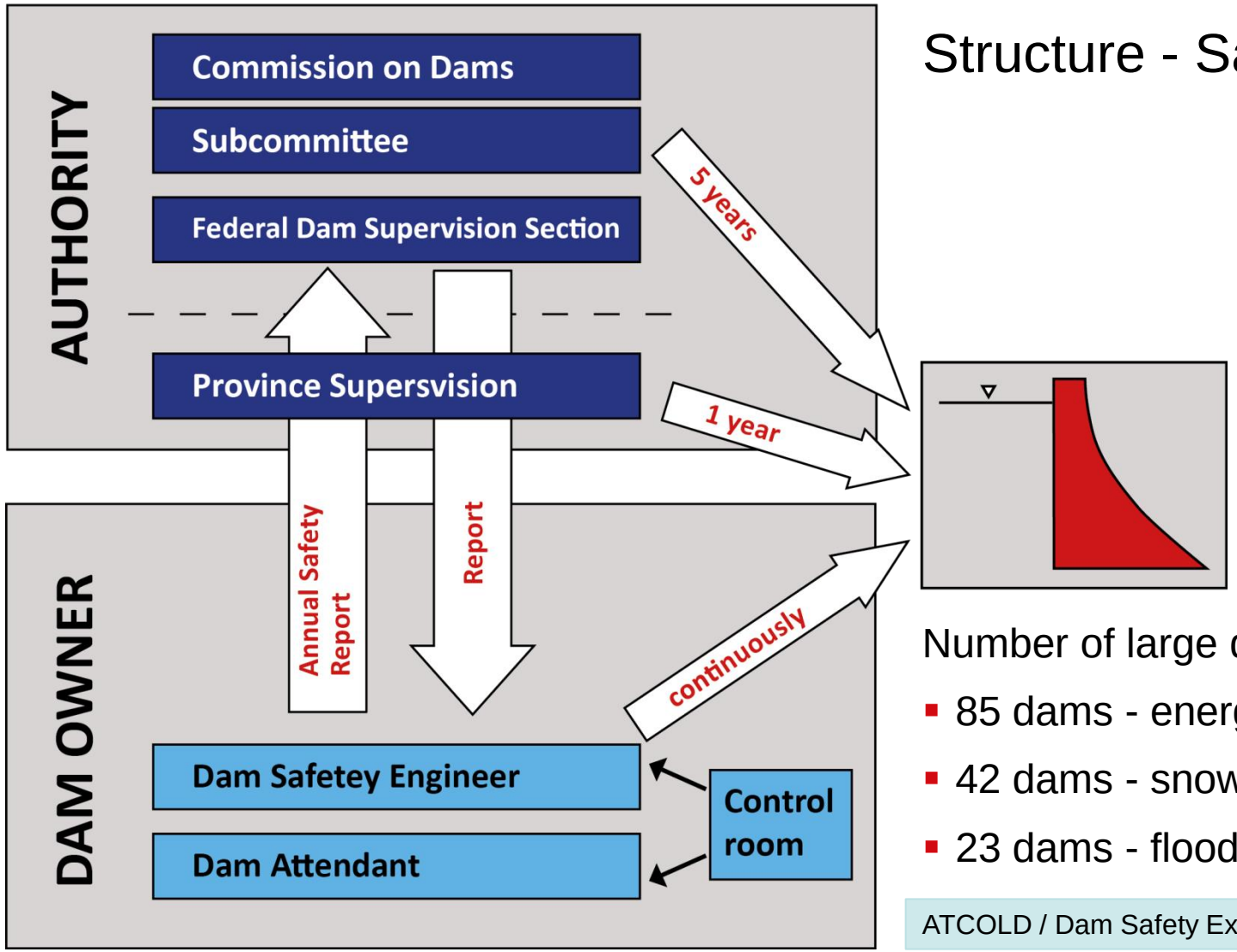
World Declaration on Dam Safety

Throughout history, the construction, operation and maintenance of dams and their storage **reservoirs have provided significant benefits to humankind**. Storage of water behind dams regulates natural streamflow, allowing for benefits resulting from increased water availability, renewable energy production and reduction of adverse impacts caused by nature's extremes of flooding and drought.

In our fragile world, growing population is causing a steady increase in demand for water, food, energy and minerals to meet basic needs as well as rising standards of living. At the same time, water storage **represents additional risks to downstream communities, property and the environment, including the potential for** dam failure, possibly resulting in an uncontrolled release of stored water.

The Dams Engineering community has a **profound ethical responsibility** to carry out its professional duties so that dams, reservoirs and levees are designed, constructed and operated in the most effective and sustainable way, while also ensuring that both new and existing dams are safe during their entire lifespan and after decommissioning.

Structure - Safe Dams



Number of large dams in Austria

- 85 dams - energy (to 200m)
- 42 dams - snowmaking (to 40m)
- 23 dams - flood mitigation

ATCOLD / Dam Safety Expert Seminar / Melbinger

ICOLD – Safe Dams

ICOLD

Member Countries

COLOMBIA

Name of the Committee:
Comité Colombiano de Grandes Presas

President:
Alberto MARULANDA

Address Committee:
Mr. Alberto MARULANDA, Chairman
Comité Colombiano de Grandes Presas
INGETEC S.A. Cra 6 No. 30a-30 BOGOTA
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E-mail: amarulapos@ingetec.com.co

ICOLD

Member Countries

AUSTRIA

Name of the Committee:
Austrian Committee on Large Dams

President:
Gerald ZENZ, Chairman

Secretary General:
Mr. Helmut KNOBLAUCH, Secretary

Address Committee:
Stremayrgasse 10/II 8010 GRAZ
AUTRICHE

Phone: (43-316) 873 8861


I.


II.


III.


IV.


V.


VI.


VII.


VIII.

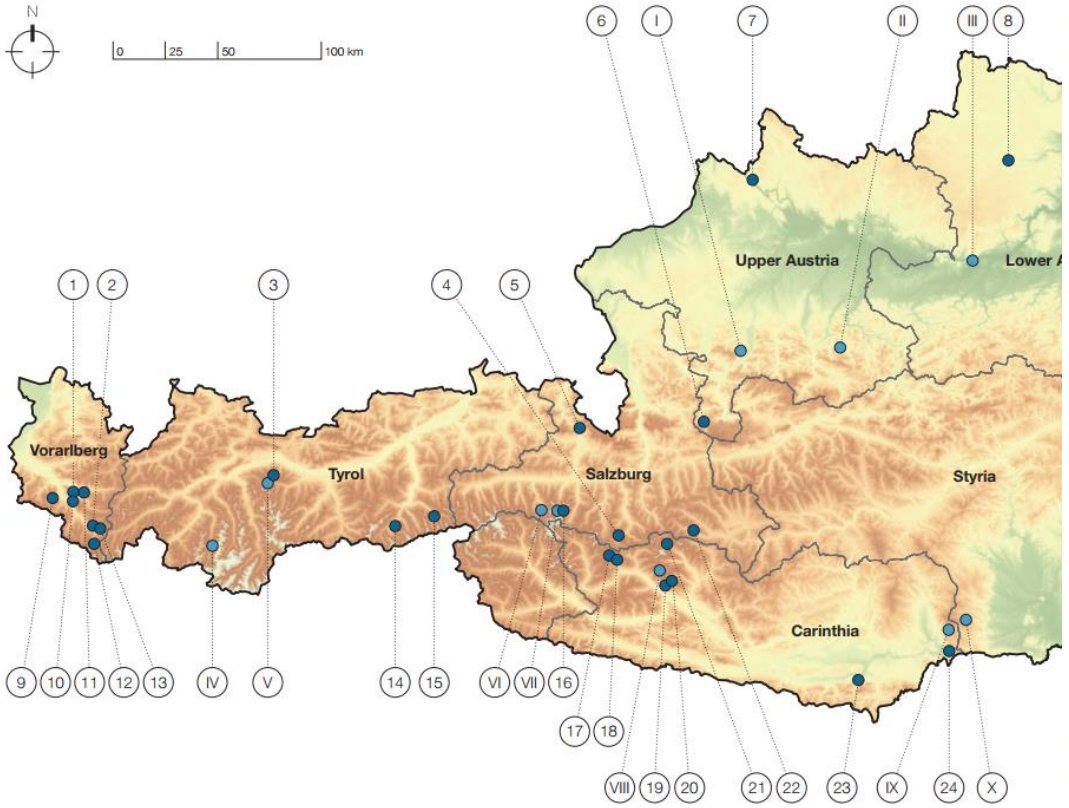

IX.


X.


XI.


XII.

High Head Pumped Storage Schemes



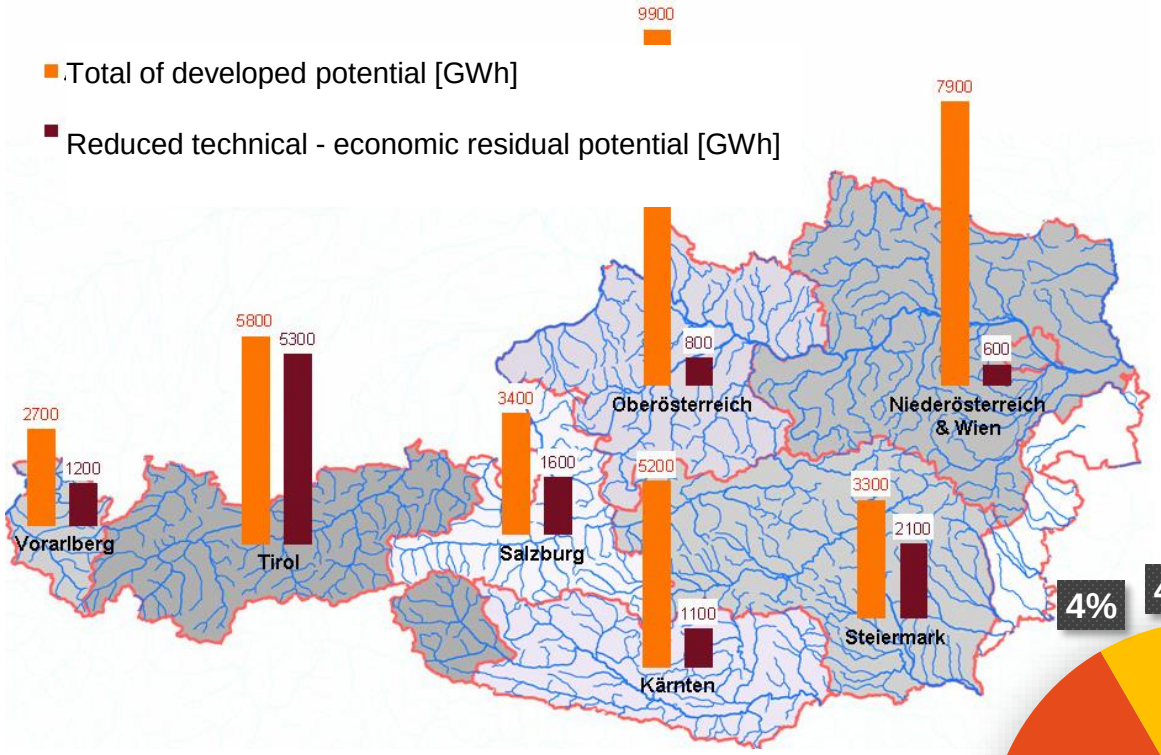
1. Obere Ill-Lünersee - Rodundwerk II
2. Obere Ill-Lünersee - Rifawerk
3. Kühtai
4. Nassfeld
5. Diessbach
6. Gosau
7. Ranna
8. Ottenstein
9. Obere Ill-Lünersee - Rellswerk
10. Obere Ill-Lünersee - Lünerseewerk
11. Obere Ill-Lünersee - Rodundwerk I
12. Obere Ill-Lünersee - Obervermuntwerk II
13. Obere Ill-Lünersee - Kopswerk II
14. Zemm-Ziller - Rosshag
15. Zemm-Ziller - Häusling
16. Kaprun Upper Stage - Limberg I, Limberg II
17. Fragant - Feldsee
18. Fragant - Innerfragant, Haselstein
19. Malta-Reisseck - Malta Main Stage
20. Malta-Reisseck - Reisseck II
21. Malta-Reisseck - Malta Upper Stage
22. Hintermuhr
23. Freibach
24. Koralpe

I. Ebensee
II. Molln
III. Sulzberg
IV. Versetz
V. Kühtai II
VI. Tauernmoos
VII. Limberg III
VIII. Reisseck II Plus
IX. St. Georgen
X. Koralm

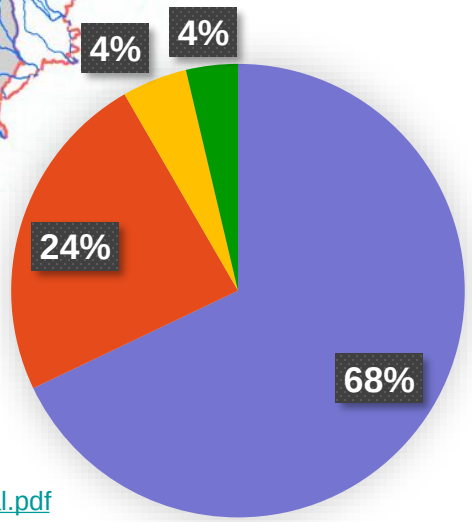
Capacity Total Hydro – 14120 MW

High Head Power Plants / Pumping – 9400 MW / 5200MW

Hydro Power Potential – 15TWh – app. 42TWh existing



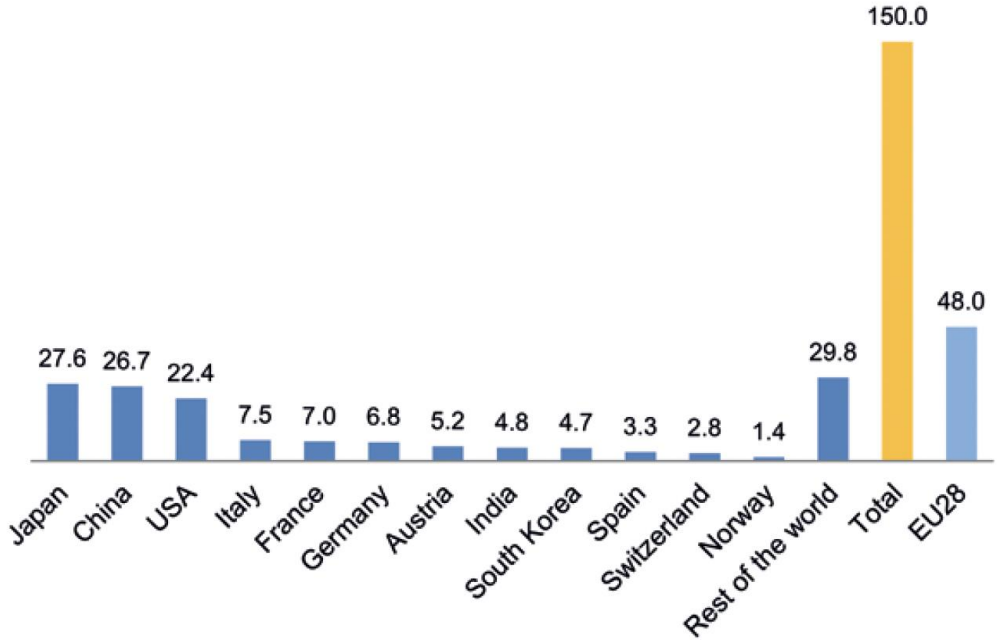
Electricity – Share (2015)



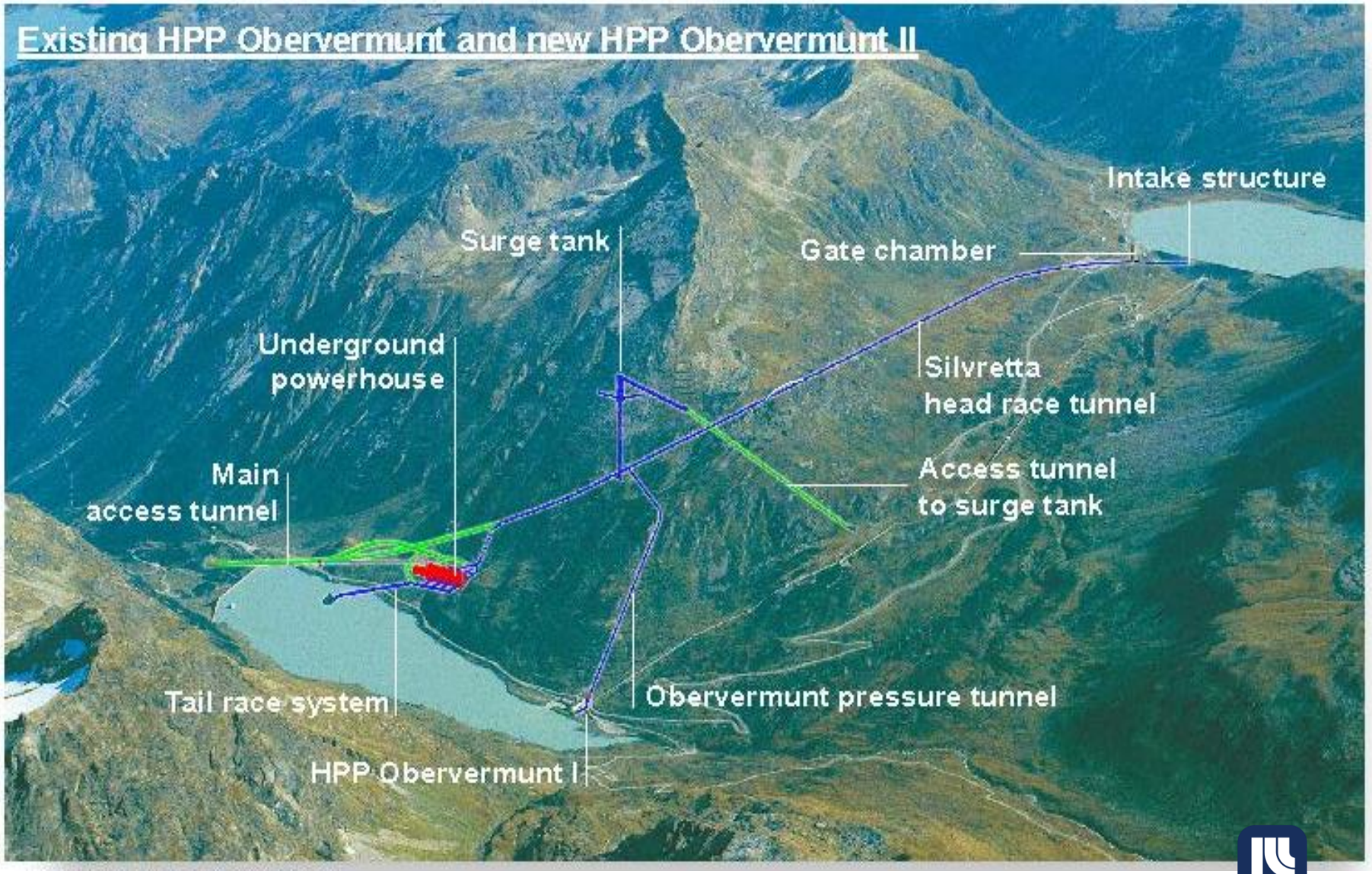
- Hydropower
- Thermal: Fossil fuels and derivatives
- Thermal: Biofuels

Source: PÖYRY - VEÖ Wasserkraftpotentialstudie Österreich
http://www.energiestrategie.at/images/stories/pdf/36_veo_08_wasserkraftpotenzial.pdf

Installation of Pumped Storage Capacity

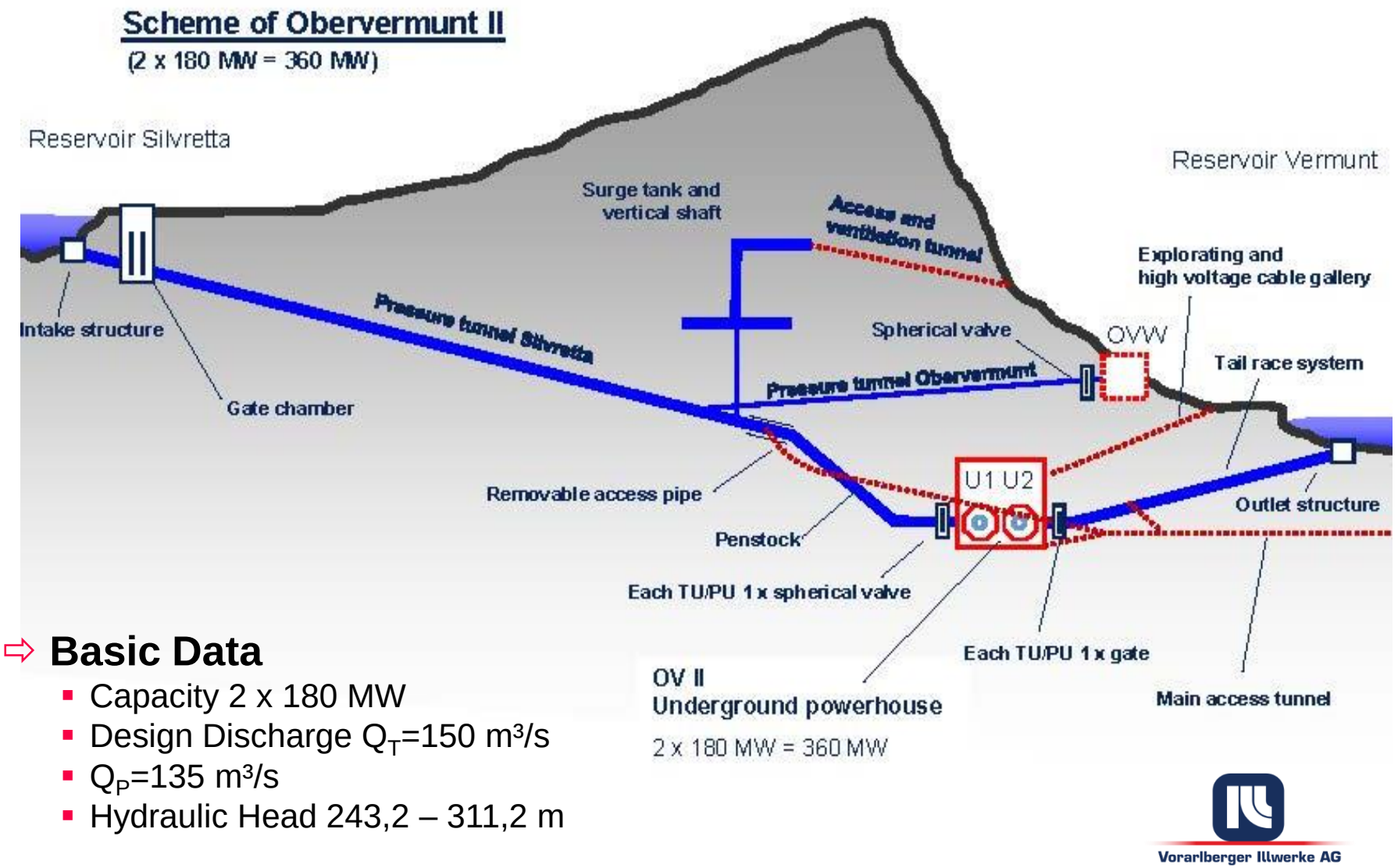


- European Union - Additionally - install 10 GW until 2030
- Target – 2050 to achieve app 80% renewable – Wind / Photovoltaic
- Dark doldrums
- Ref.: IHA Hydropower Status Report 2017



Wolfgang Richter: Surge Tank Design for Flexible Hydropower

Vorarlberger Illwerke AG



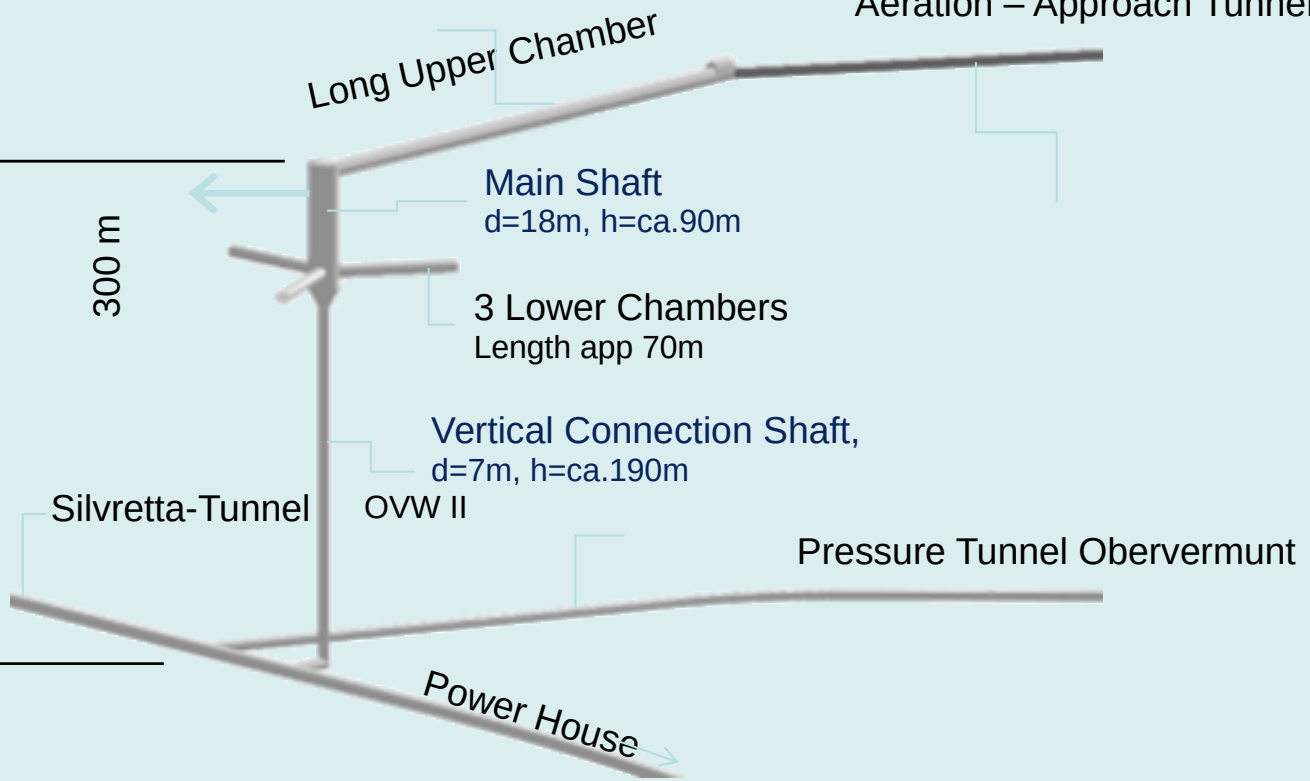
⇨ Basic Data

- Capacity 2 x 180 MW
- Design Discharge Q_T=150 m³/s
- Q_P=135 m³/s
- Hydraulic Head 243,2 – 311,2 m

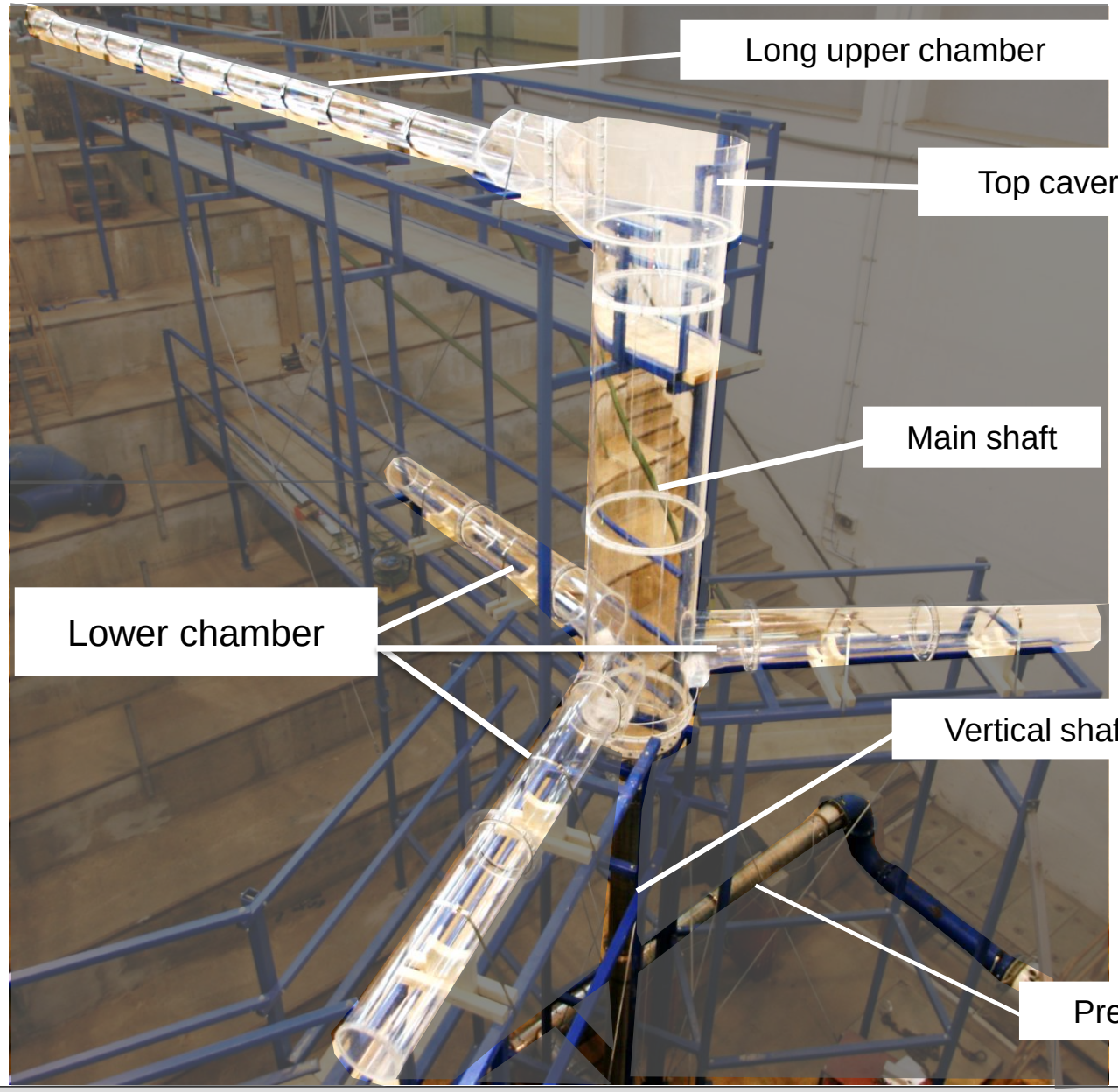
Vorarlberger Illwerke AG

Wolfgang Richter: Surge Tank Design for Flexible Hydropower

Surge Tank Krespa



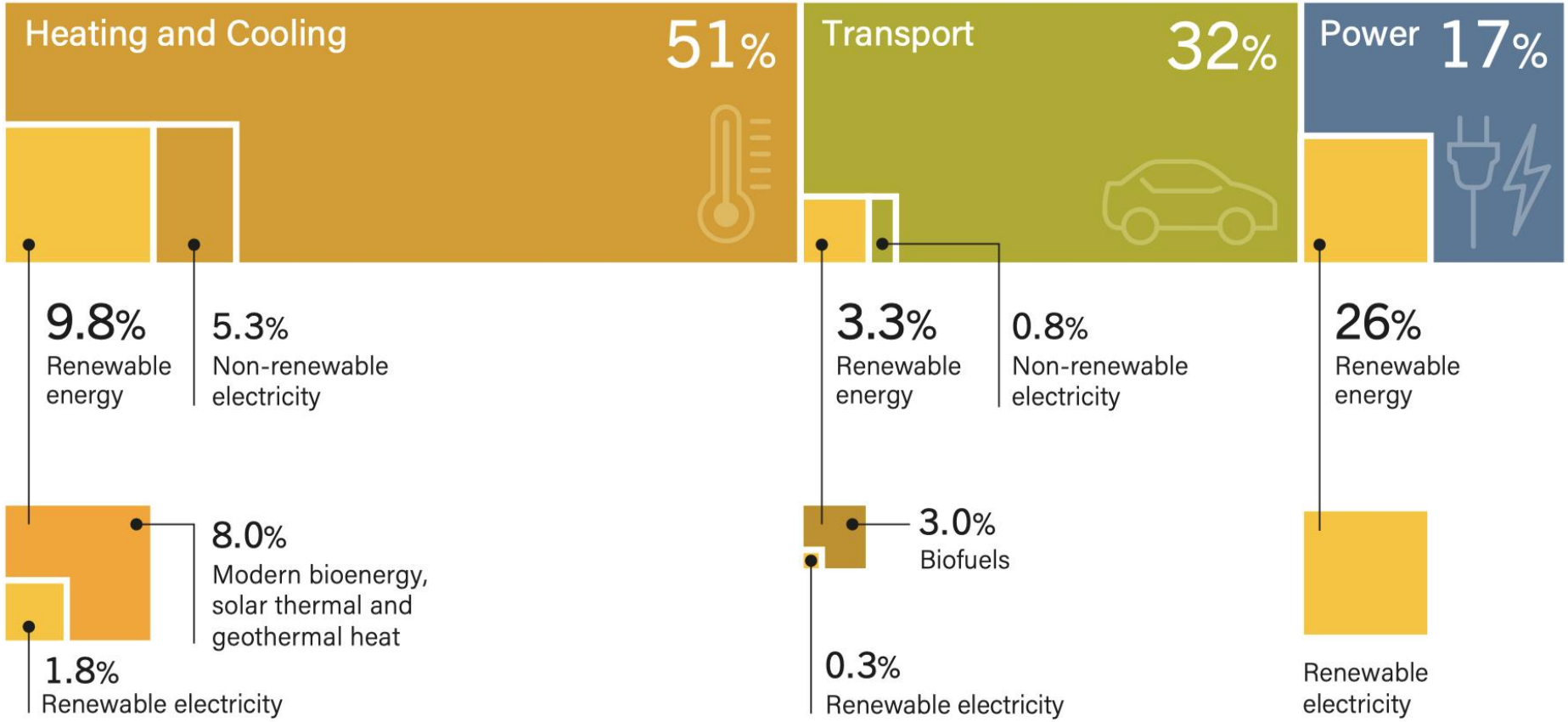
Vorarlberger Illwerke AG



Krespa
Modell Scale
1:30

Vorarlberger Illwerke AG

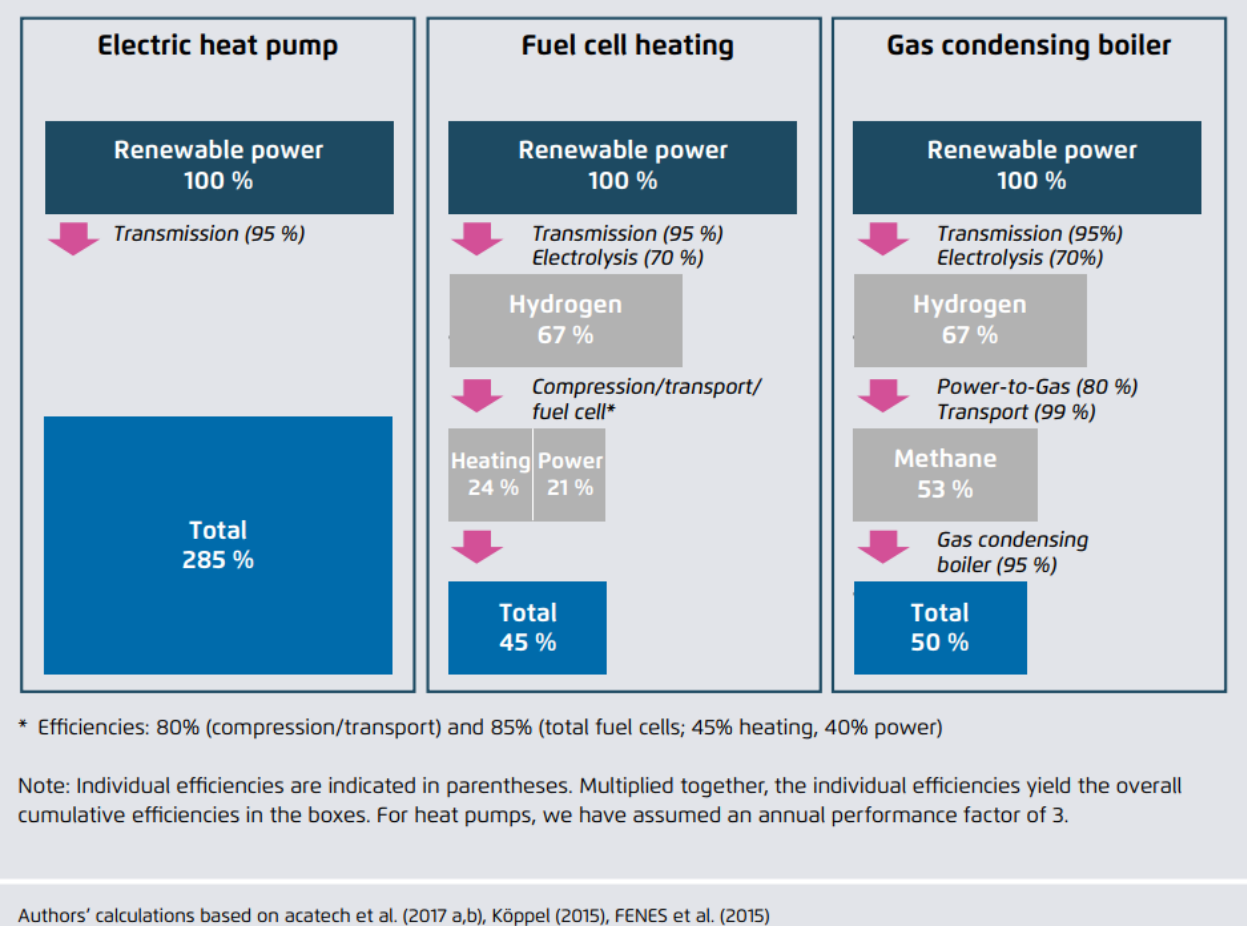
Renewables – Different Sectors



Source: REN21, Global Status Report 2019

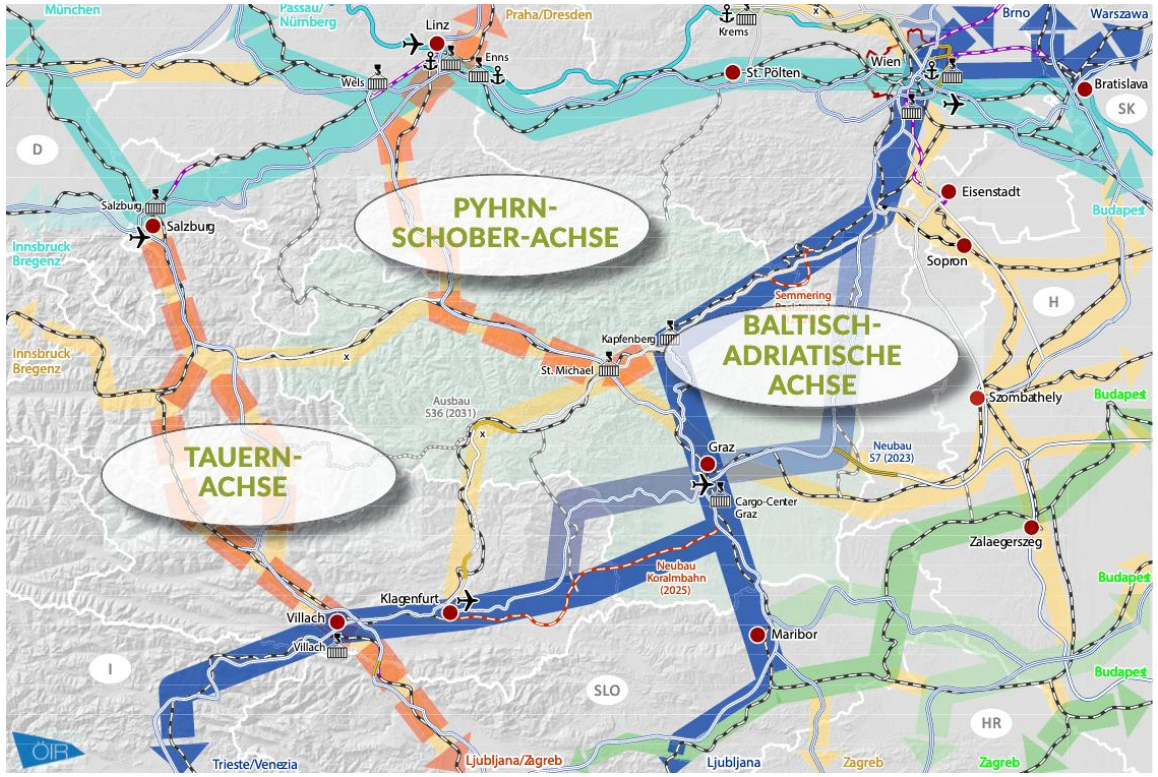
50% Heating – Cooling // 30% Traffic // 20% Electricity

Electric Energy– Efficiency - Heating



Agora - Frontier Economics (2018): The Future Cost of Electricity-Based Synthetic Fuels - www.agora-verkehrswende.de

Public Transportation - Railway



Truck Transport

40% of all CO_2 Emissions

Target to increase attractivity and availability of transport of goods

Eine Initiative von:

Das Land Steiermark

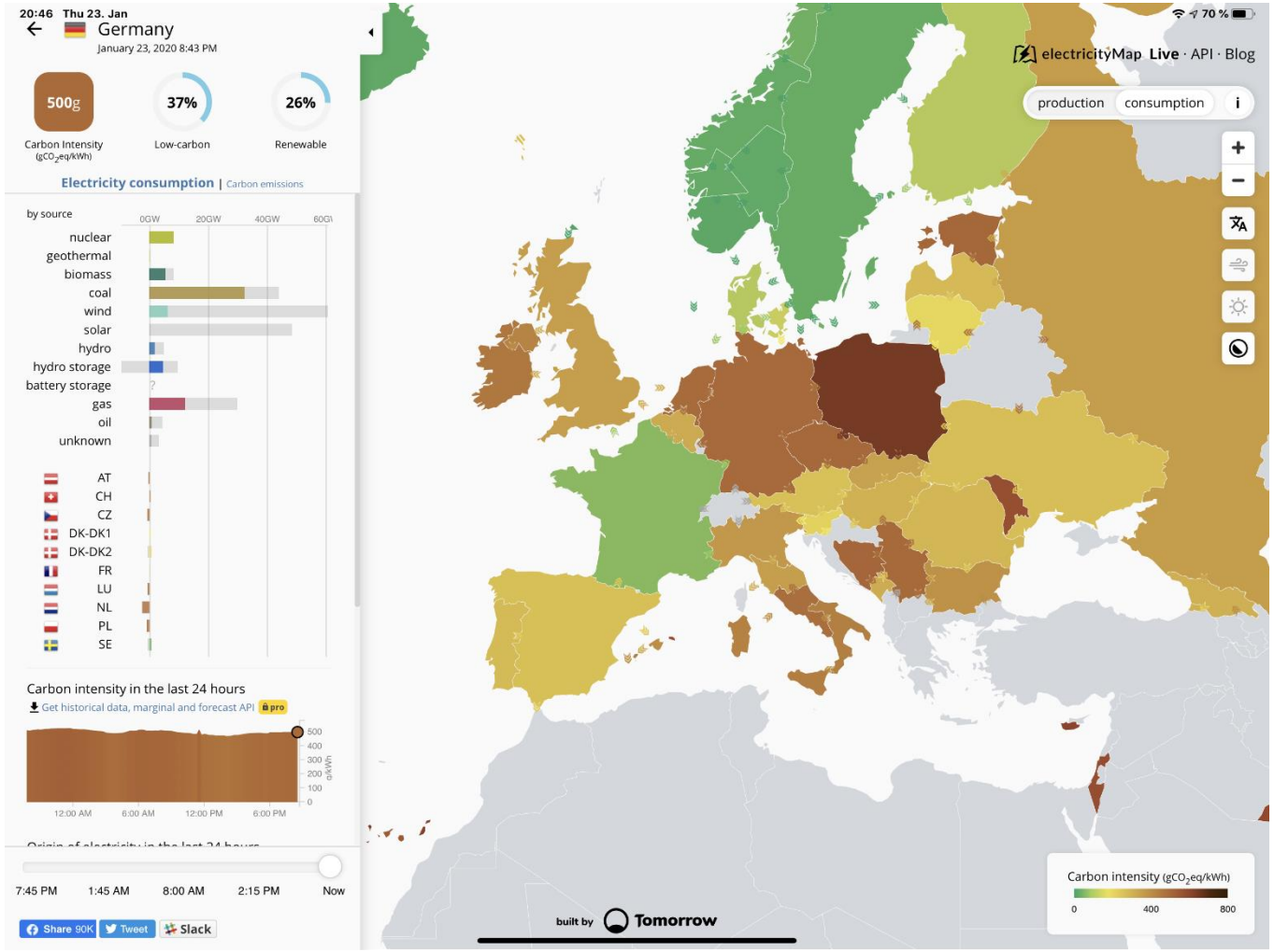
AK www.akstmk.at

iv INDUSTRIELLENVEREINIGUNG STEIERMARK

ÖGB

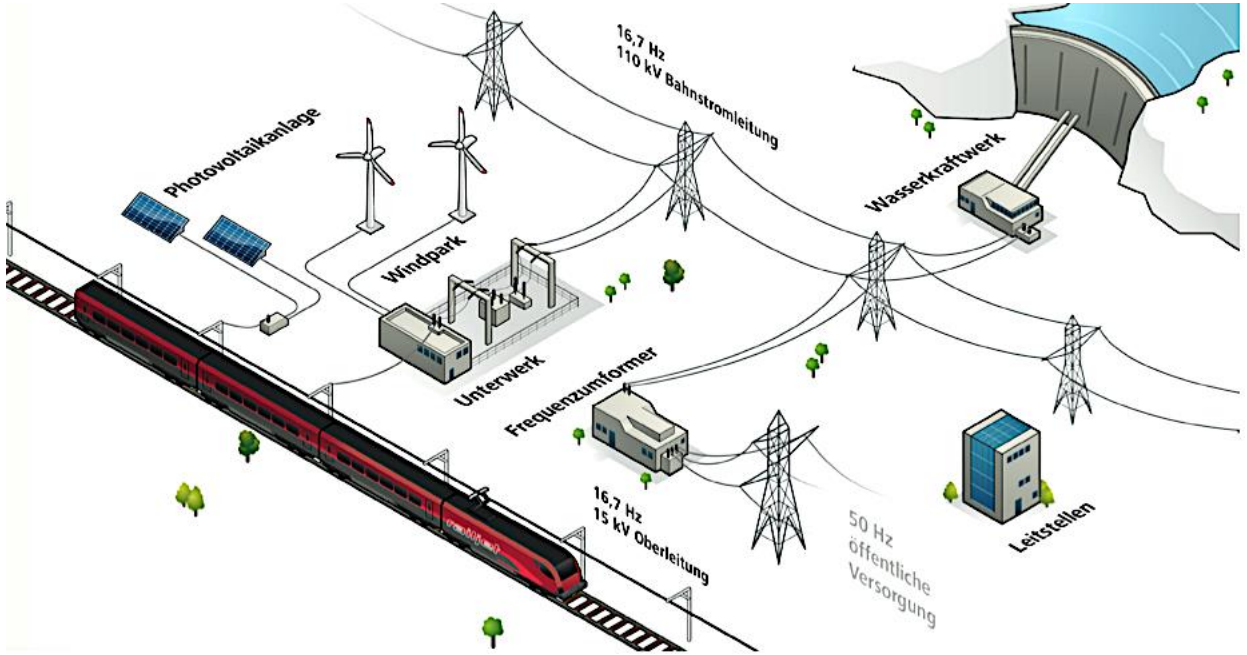
WKO STEIERMARK

Effect - Electricity Map – Europe – CO_2 emissions [g/kWh]



- Traffic
  - Car 0,25kWh /km
    - 500g CO_2 /kWh
    - 125g CO_2 /km
- Diesel Car
  - 100g CO_2 /km
- Entire Individual Traffic in AT – 15TWh

Railway – electrification in Austria



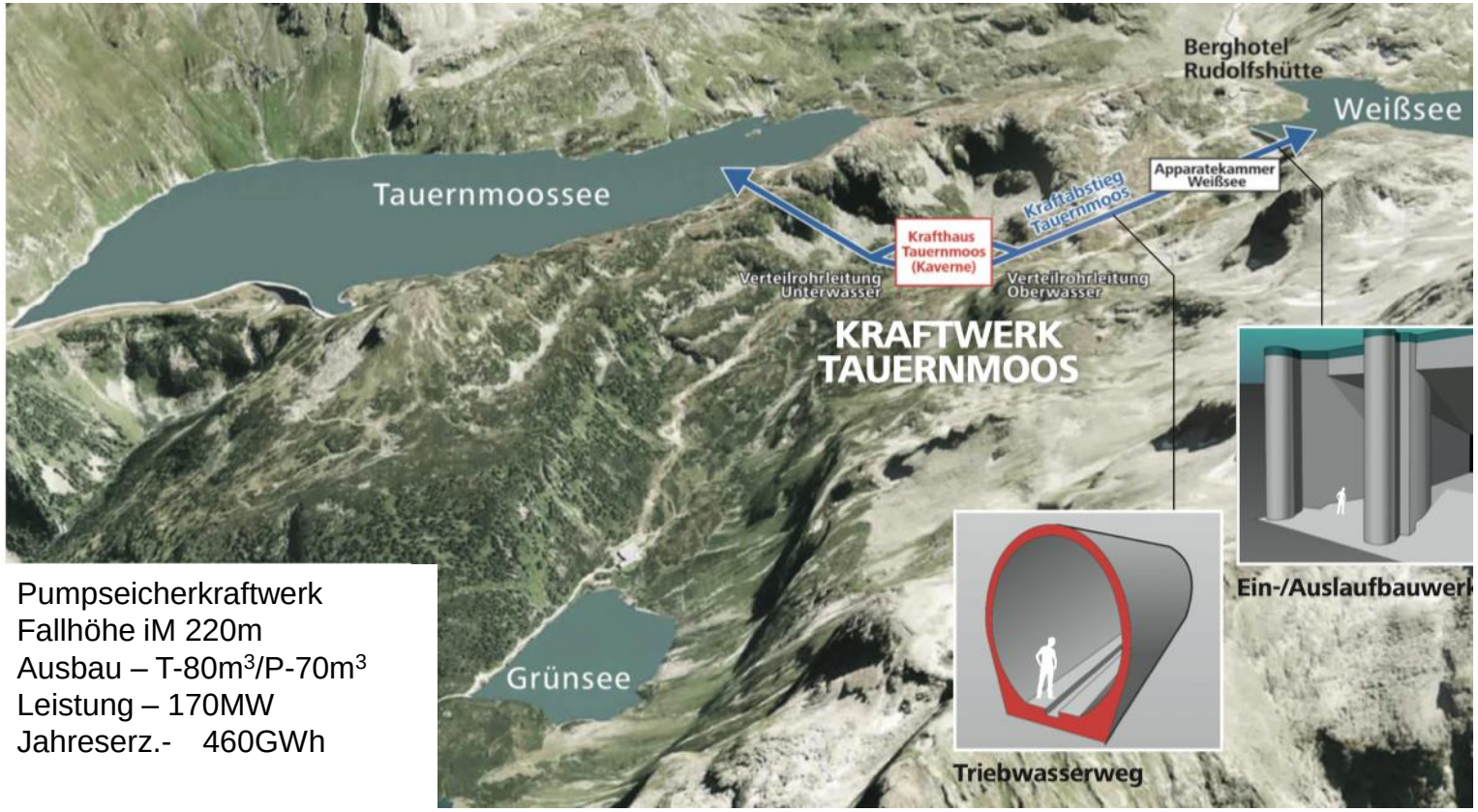
ÖBB INFRA

Austria - 100% from renewable energy sources

1,9 TWh – Annual Consumption – (16.7Hz)

- 33% from ÖBB owned hydro power plants
- 25% from Associated Partners
- Remaining from Austrian Grid

Pumped Storage Scheme Tauernmoos – Operation 2026



Pumpseicherkraftwerk
Fallhöhe iM 220m
Ausbau – T-80m^3/P-70m^3
Leistung – 170MW
Jahreserz.- 460GWh

ÖBB INFRA

Reference: Kraftwerk Tauernmoos – Projektbroschüre 2019

https://infrastruktur.oebb.at/en/projects-for-austria/traction-current/power-stations-frequency-converters/power-station-tauernmoos/projektbroschuere-tauernmoos.pdf Abfrage:Feb.2020

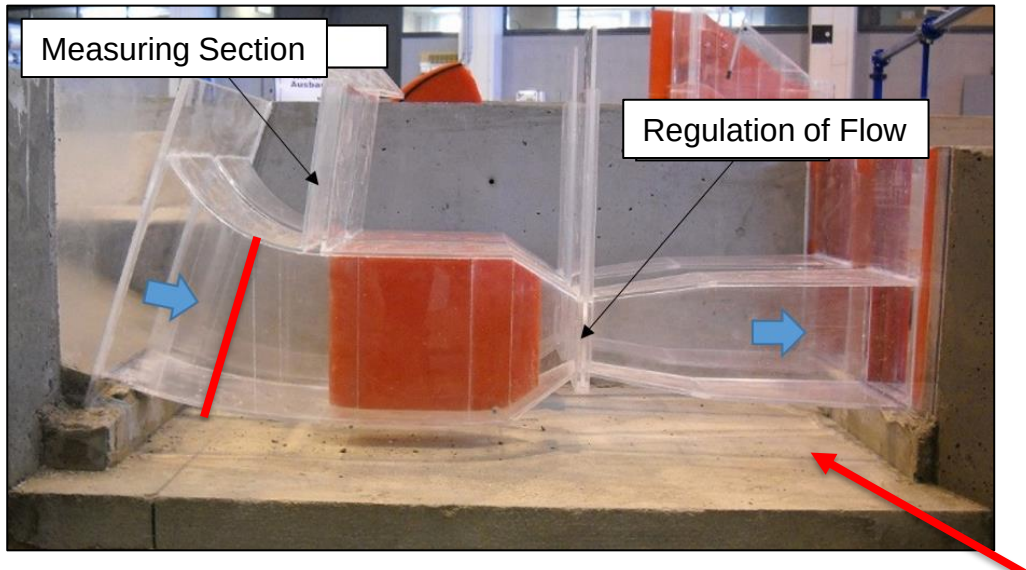
Smart Cities - Smart Hydropower – Graz – Power

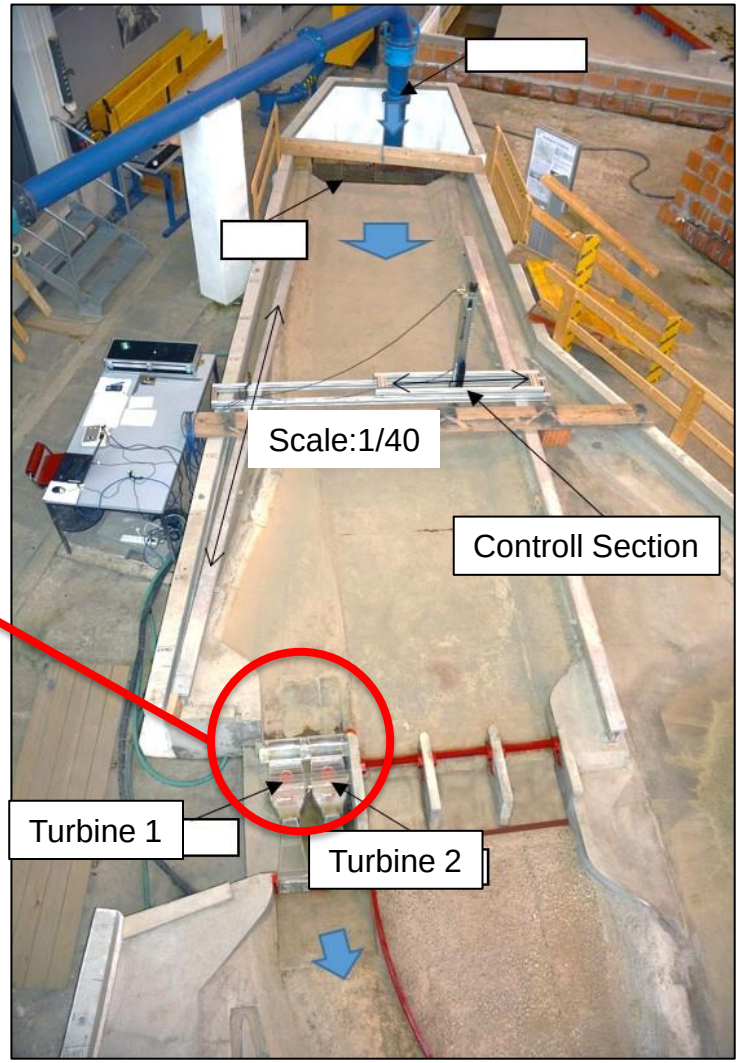
ENERGIE STEIERMARK

- Electricity from Renewable Sources
- Hydrology
  - Ecological flow
- Fish Migration
  - Up- and downward
- Morphology
  - Continuity
- Flood protection

- Recreation
- Green City

Hydraulic Modell Tests – Rehabilitation - Optimization





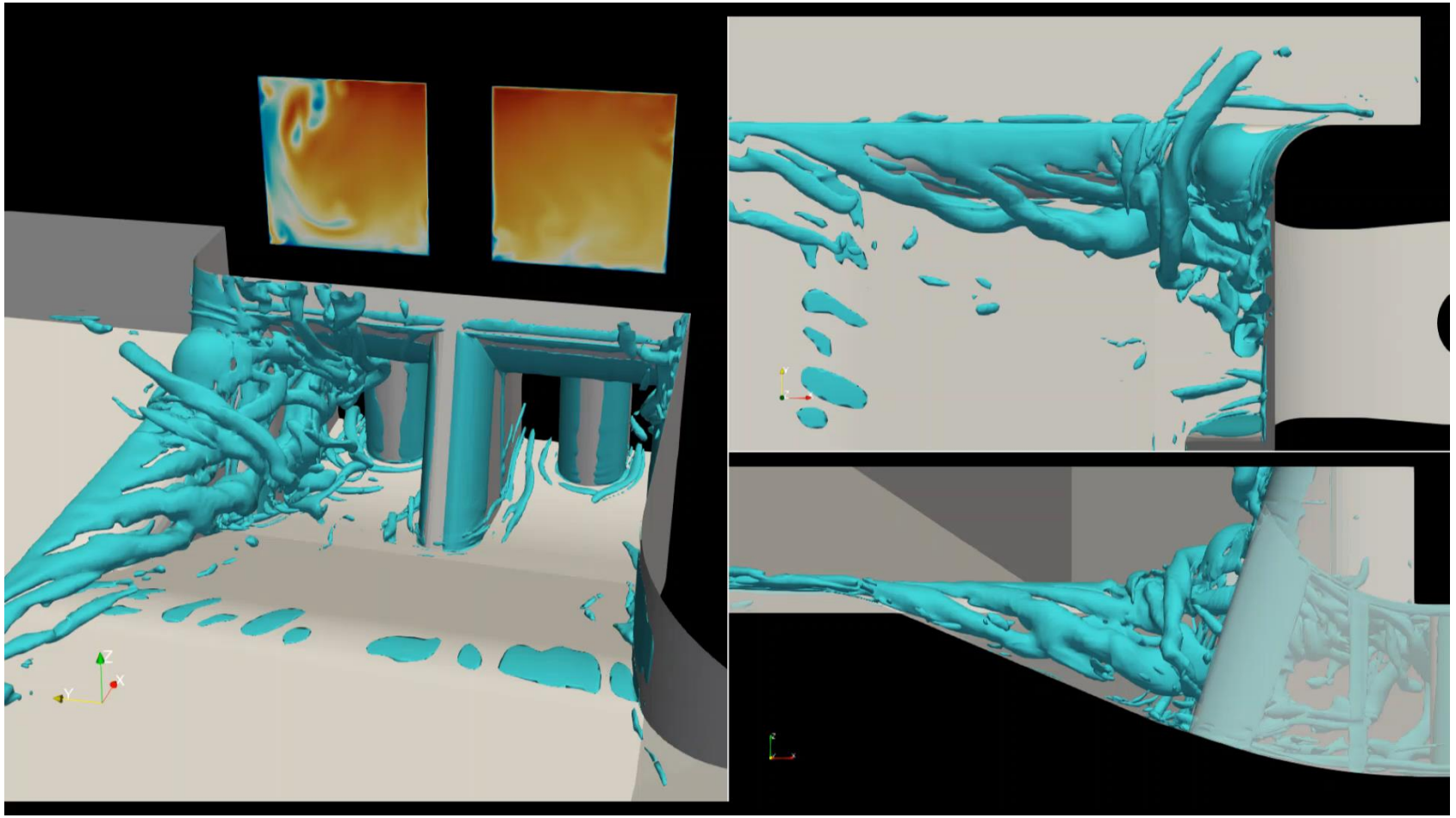
Optimization - Capacity 3%-5%

Shape of approach flow channel

Transition – Change in inclination

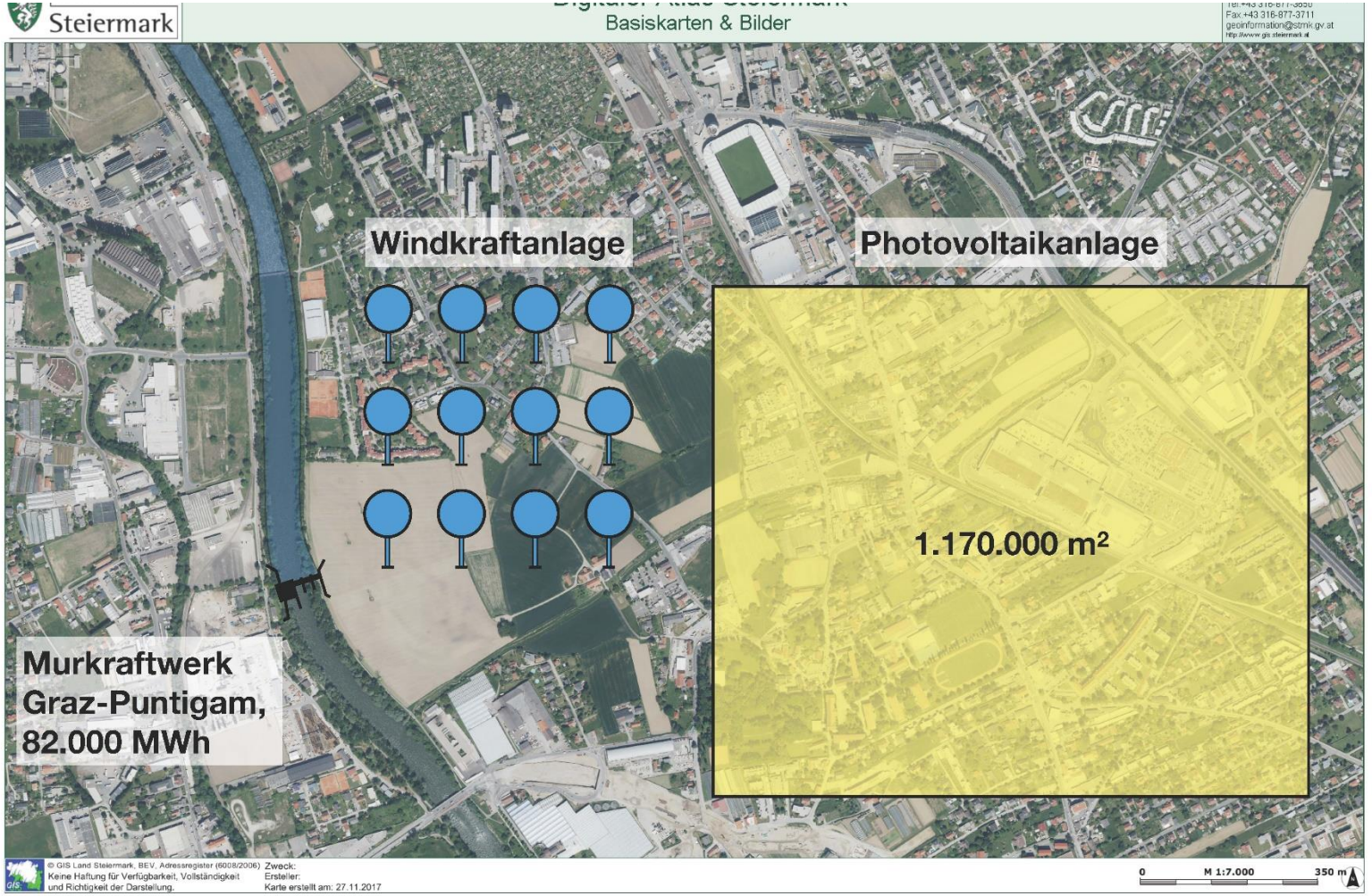
Trash Rack

Simulation of Approach Flow



3% Optimization – Leads to 2,4GWh at RoR Plant

Comparison – Required Area



Climate Change – Mitigation Measures - Flood Events








Development of Strategies to optimize flood risk management in Styria

Water Resources Management
Amt der steiermärkischen Landesregierung

Quelle Abb.:NEWSAT, http://www.news.at/a/bilder-oesterreich-hochwasser-244897 (Stand 23.06.2014)

Engineering Education - Graz University of Technology


AUTUMN 2015
TU Graz
Graz University of Technology
MASTER'S PROGRAMME
Geotechnical and Hydraulic Engineering
TAUGHT IN ENGLISH
4 SEMESTERS 90 ECTS + 30 ECTS Master Thesis
Compulsory Courses
• Soil Mechanics and Foundation Engineering (4.0 ECTS)
• Rock Mechanics and Tunneling (4.0 ECTS)
• Hydraulic Engineering (4 ECTS)
• etc.
27,5 ECTS
Electives Catalog 1
1a Hydraulic Engineering
1b Soil Mechanics
1c Rock Mechanics
• Earthquake Analysis of Hydraulic Structures (3.0 ECTS)
• Computational Geotechnics (6.0 ECTS)
• Landslides and Slope Processes (3.0 ECTS)
• TBM excavation (2.0 ECTS)
• etc.
30 ECTS
Electives Catalog 2
• Numerics in Hydraulic Engineering (4.5 ECTS)
• Design of Pressure Conduits (3.0 ECTS)
• Geotechnical risk assessment (3.0 ECTS)
• etc.
20,5 ECTS
Soft Skills
Elective
6 ECTS
Free Electives
Elective
6 ECTS

Education and Training – Young Engineers

Create Network – encourage attandance to ICOLD meetings

Provide opportunity for **knowledge transfer** to next generation

Provide platform for ***Young Engineers*** to exchange

Inspire Young Engineers to be active in National Committees

Austrian National Committee on Large Dams

2nd Experts Seminar

KAPRUN, Province of Salzburg
AUSTRIA

Dam Surveillance Practice

Do be

Aware of

Multiple benefits &

Sustainable effects