# Dams & Reservoirs serve for a Better World

Gerald Zenz
Graz University of Technology
Chair of Hydraulic Engineering and Water Resources Management
ICOLD - Vice President – Europe; ATCOLD - President

## Content of Presentation

Necessity of Dams – Contribution to Prosperity

- Irrigation; Water supply
- Energy Production
- Flood Mitigation

Development

- Austrian National Committee on Large Dams
- Academic Education – Hydraulic Engineering

Role of ICOLD – Dam Safety Declaration

- National and Technical Committee‘s Contribution

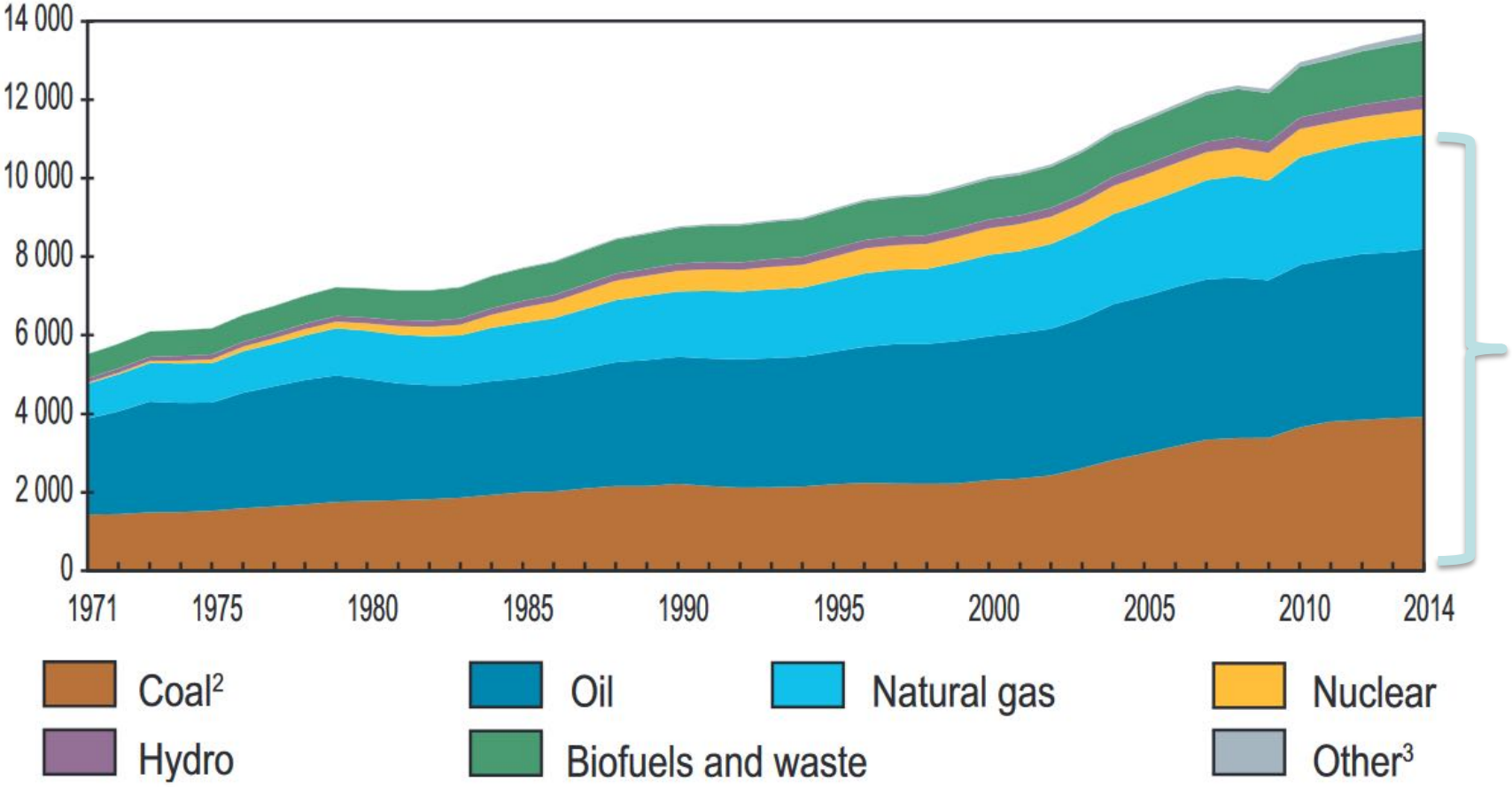
# Dams for a better world

Pic.: Verbund

## Role of Dams

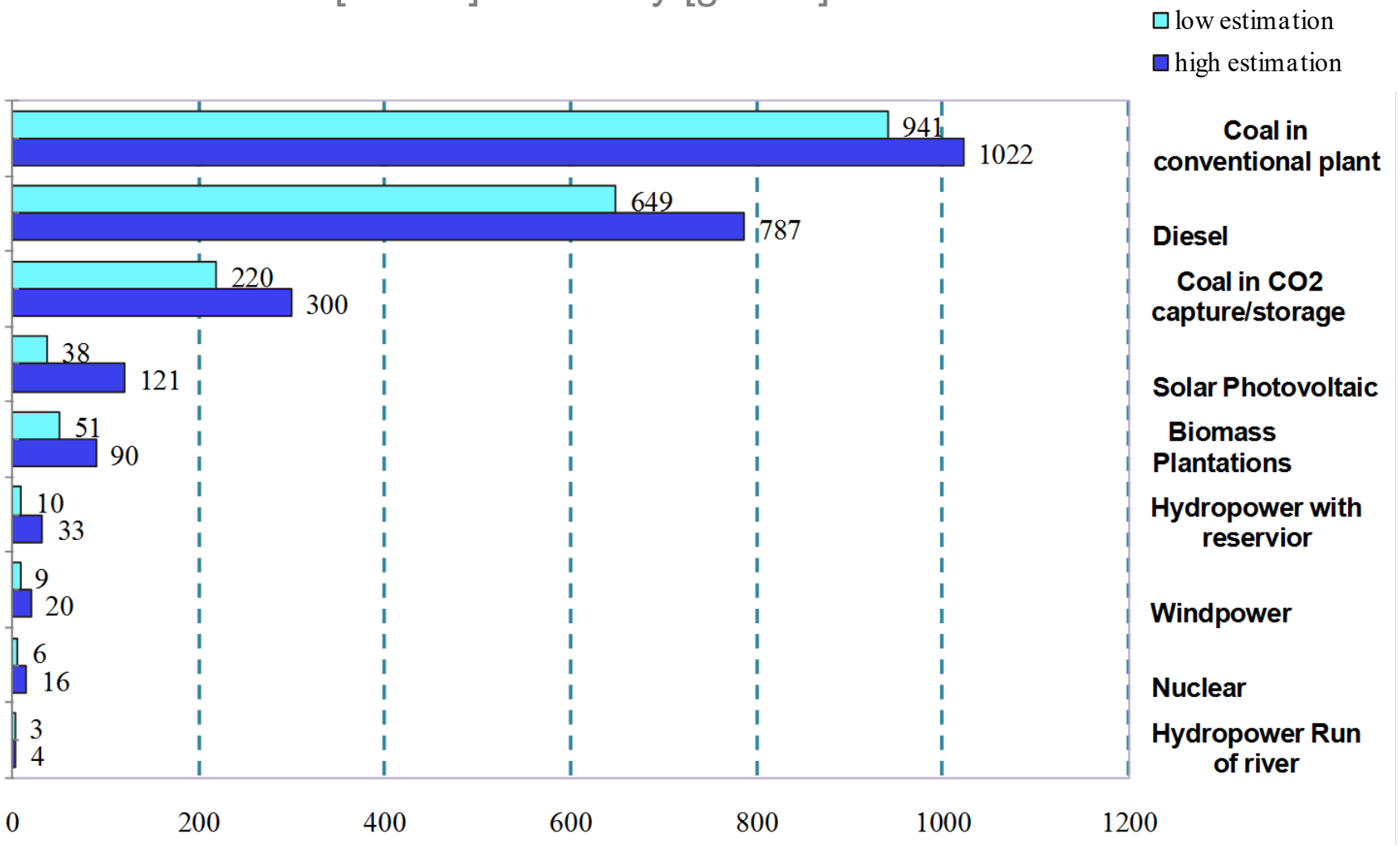
- Hydropower
- Flood Mitigation / Irrigation
- Reservoirs – Snow Production
- Navigation
- Recreation
- Improving flow conditions during dry conditions

# Climate Change - World Energy Demand 1971 to 2014 (in Mtoe ~ 11,6 TWh )



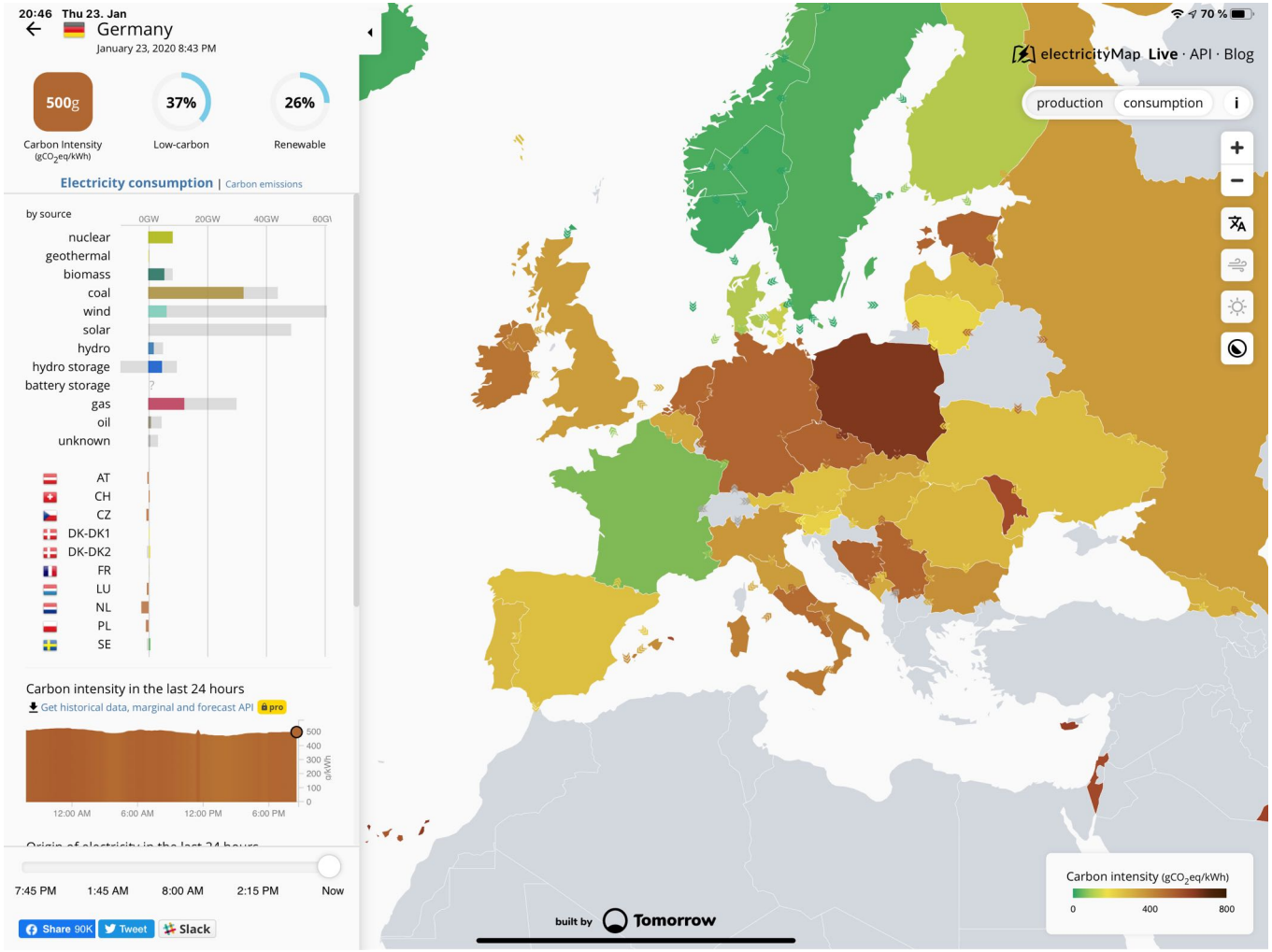

Source: IEA, https://www.iea.org/publications/freepublications/publication/KeyWorld2016.pdf

# CO2 Emission – [t/GWh] electricity [g/kWh]



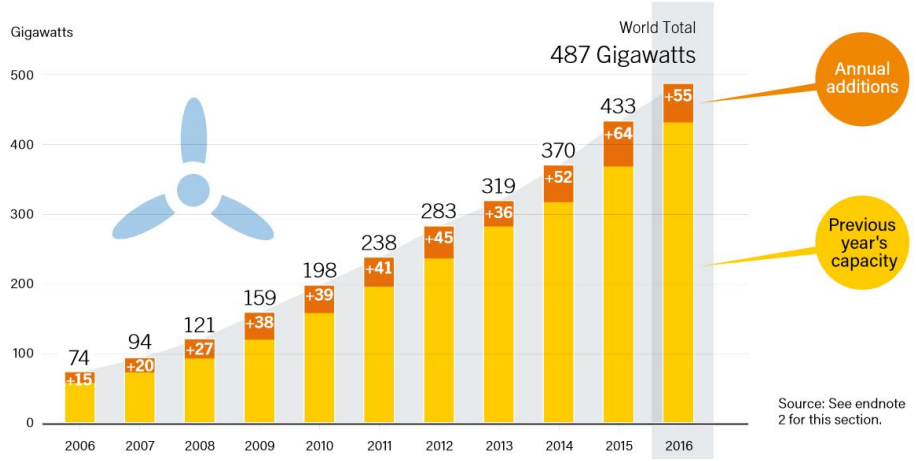

Source: Hydro Quebec; CHINCOLD – J. Jia

# Electricity Map – Europe – $CO_2$ emissions [g/kWh]




- Traffic
  - Car 0,30kWh /km
    - 500g $CO_2$ /kWh
    - 150g $CO_2$ /km
- Diesel car
  - 100g $CO_2$ /km

# Sustainable Hydro - Renewable - PV – Wind - Hydro

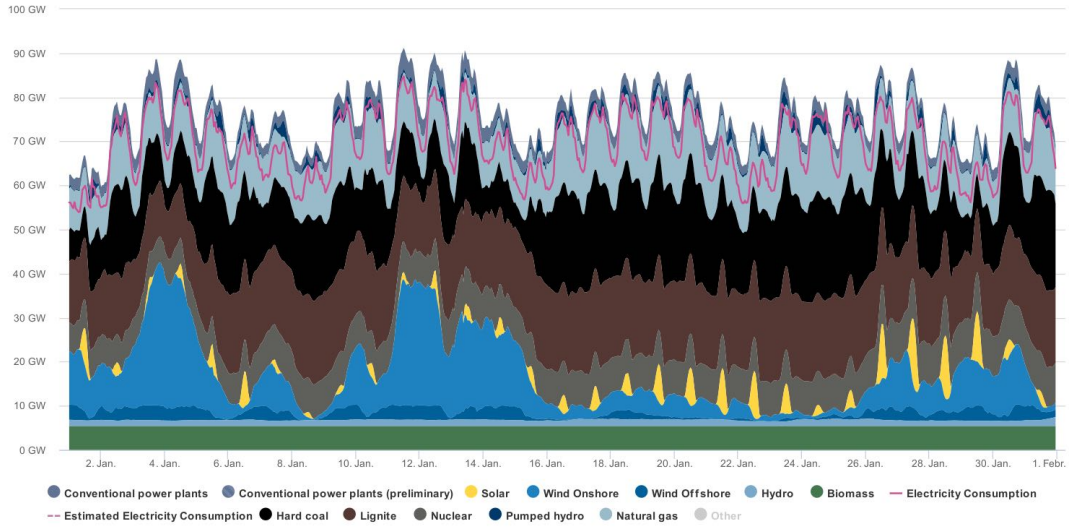



Electricity Production / Consumption, **GermanyJan 2017**

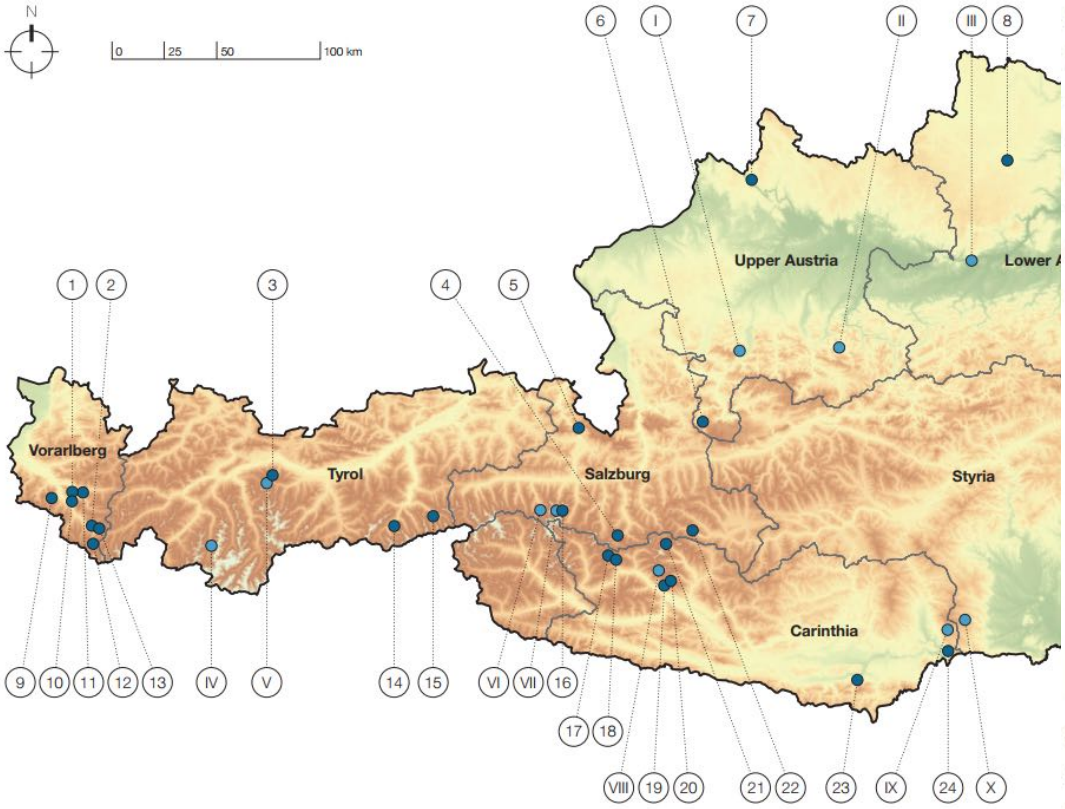
High Volatility
Flexibility

Storage Capacity
Pumped Hydro Plants

Growing Energy Demand



# 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 – 14 120 MW

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

# Kaprun – Limberg / Mooserboden

Pic.: Verbund

**Hydro Power**
Flood Protection
Drinking Water
Irrigation

**Safety Concept**
Structural
Monitoring
Operation

**Risk Assessment**
Structural Safety
Risk Management
Education

# Flood Protection with Reservoirs

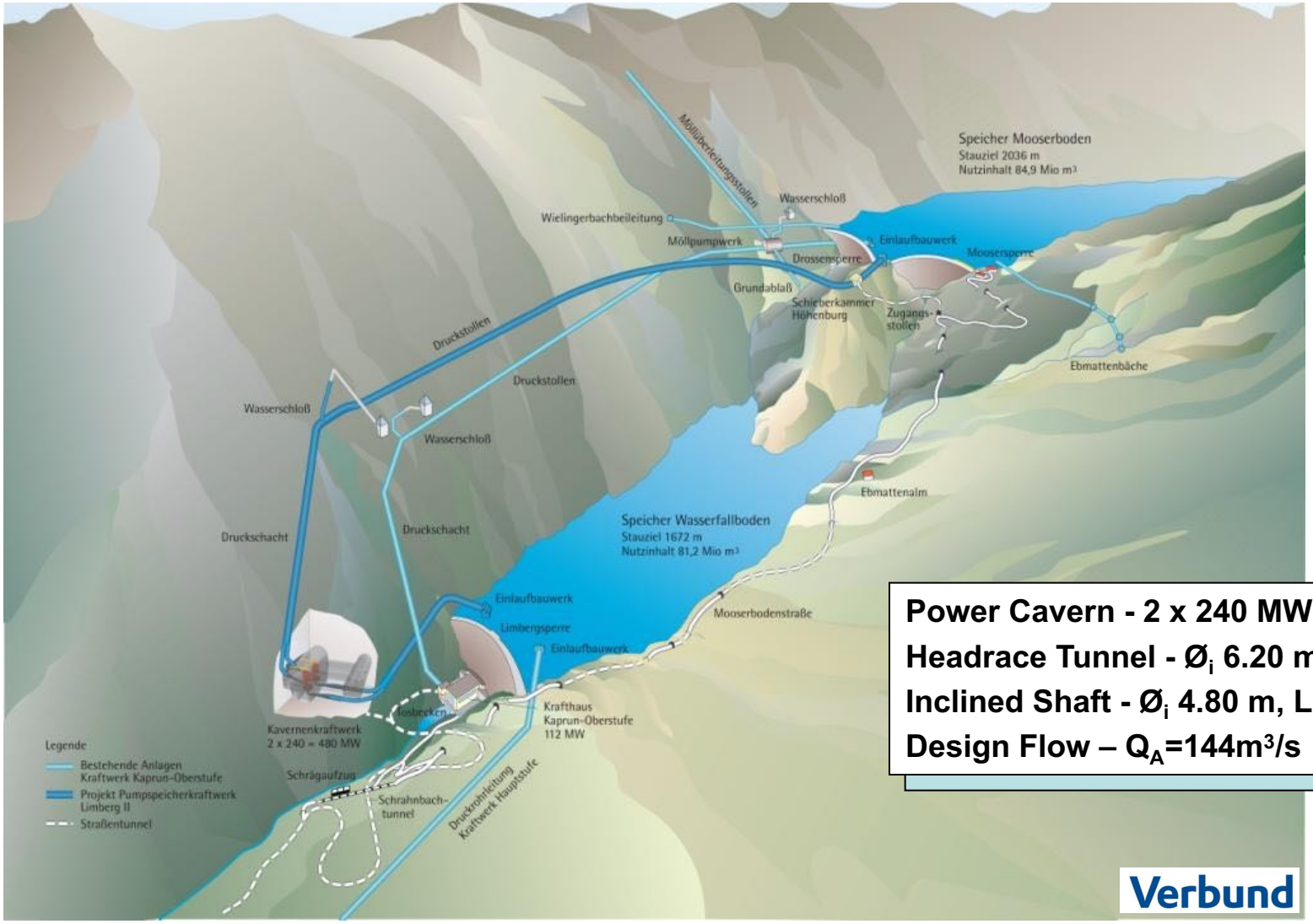
Essential Contribution to flood protection and retention

Run-of-River Plants

Reservoir Power Plants

Run Off – Retention and Retention Reservoirs

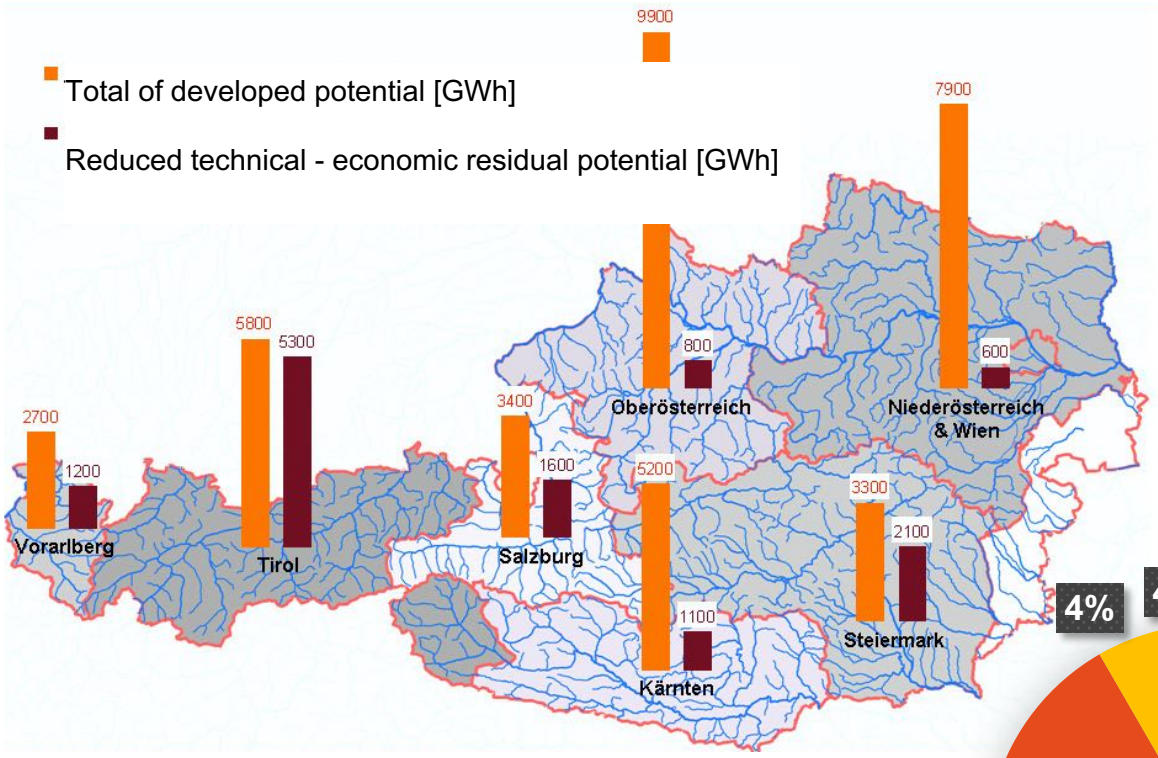
# Pumped Storage Scheme – Limberg II



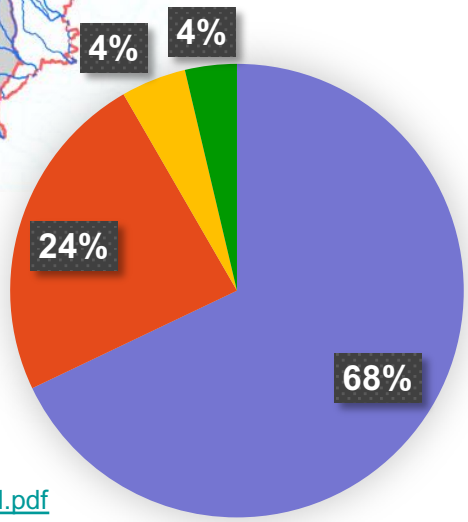

**Power Cavern - 2 x 240 MW**
**Headrace Tunnel - Ø$_i$ 6.20 m, Lg. 4km**
**Inclined Shaft - Ø$_i$ 4.80 m, Lg. 0.6 km**
**Design Flow – $Q_A$=144m³/s**

Verbund

# 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

# Smart Cities - Smart Hydropower – Mur-Graz – River Hydro Power

ENERGIE STEIERMARK

Electricity from Renewable Sources

Hydrology

- Oecological flow

Fish Migration

- Up- and downward

Morphology

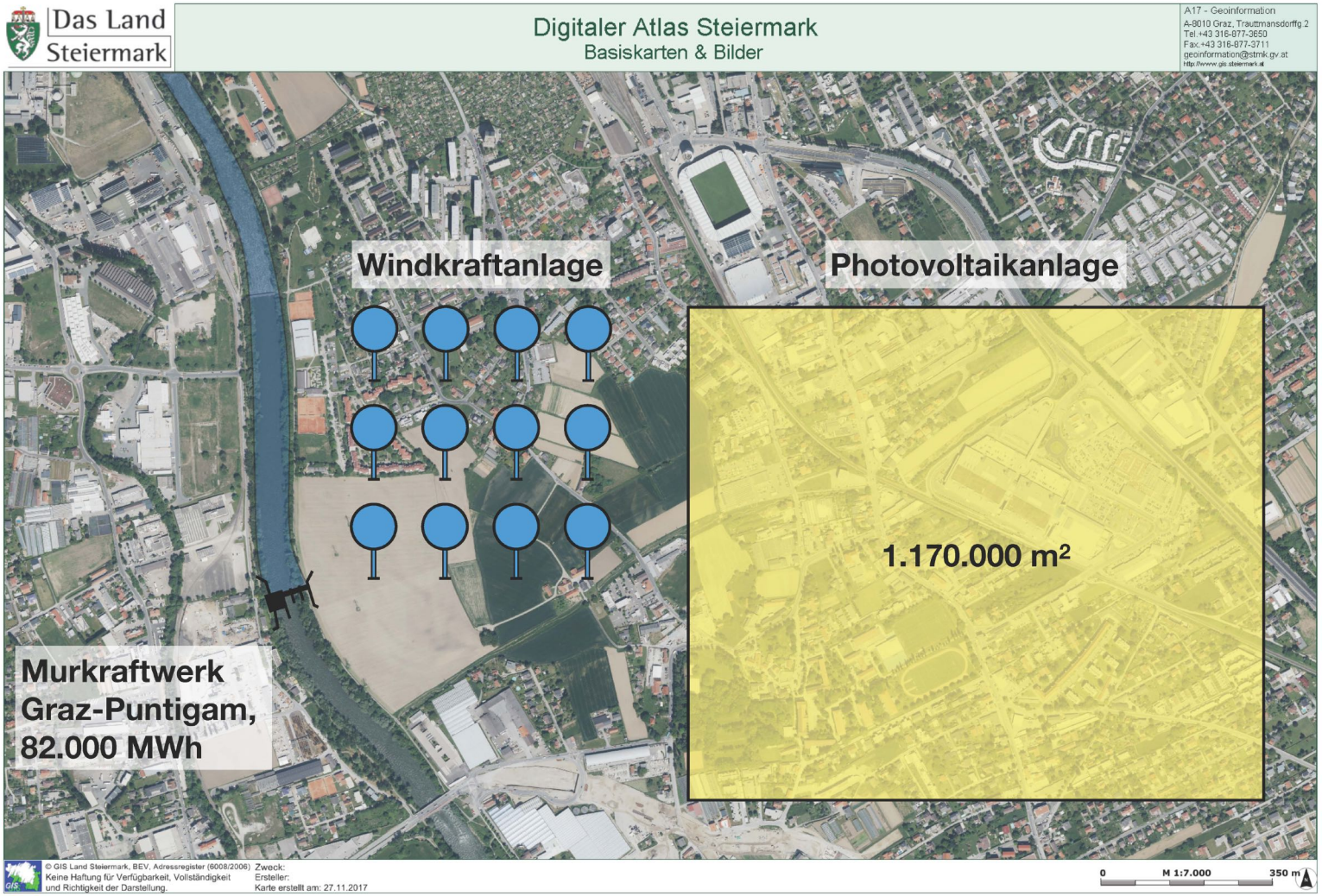
- Continuity

Flood protection

Recreation

Green City

# FLÄCHENVERBRAUCH Erneuerbarer, äquivalent zum JAV des Murkraftwerks



ATCOLD
Österreichisches Nationalkomitee für Talsperren

Seit 80 Jahren im Dienste der Talsperrensicherheit

# 06. Juni 2013

80⁺ Jahre - Staubeckenkommission Mitglied der ICOLD
50⁺ Jahre - Österreichisches Nationalkomitee für Talsperren

Sichere Talsperren - Sichere Infrastruktur



# Dam Safety – Large Dams
## Historical Development in Austria

- **1916 a flood mitigation reservoir embankment dam failed during heavy rainfall**
  caused a lot of victims and economic losses

Pic.: H.Czerny

# Dam Safety – Large Dams
## Historical Development in Austria

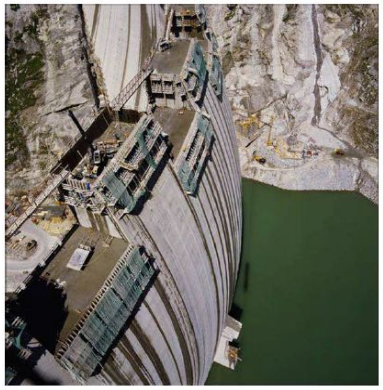
- **1916 a flood mitigation reservoir embankment dam failed during heavy rainfall**
  caused a lot of victims and economic losses
- **1918 "Austrian Dam Commission" (ADC) was founded**
  to avoid such disasters in the future
  - This commission is a panel of experts in all fields of Dam Engineering. Must be consulted by authorities in cases of new dam projects.
  - Dam Height > 15m or reservoir capacity > 500.000m$^3$.
- 1928 – Founding - International Commission on Large Dams - **ICOLD**
- 1931 – First General Assembly Meeting of **ICOLD** –

Pic.: H.Czerny

State of the Art Guidelines – Dams are different from other Civil Structures

# Austrian Dam Commission elaborate specific guidelines

Guideline
stability evaluation
concrete dams

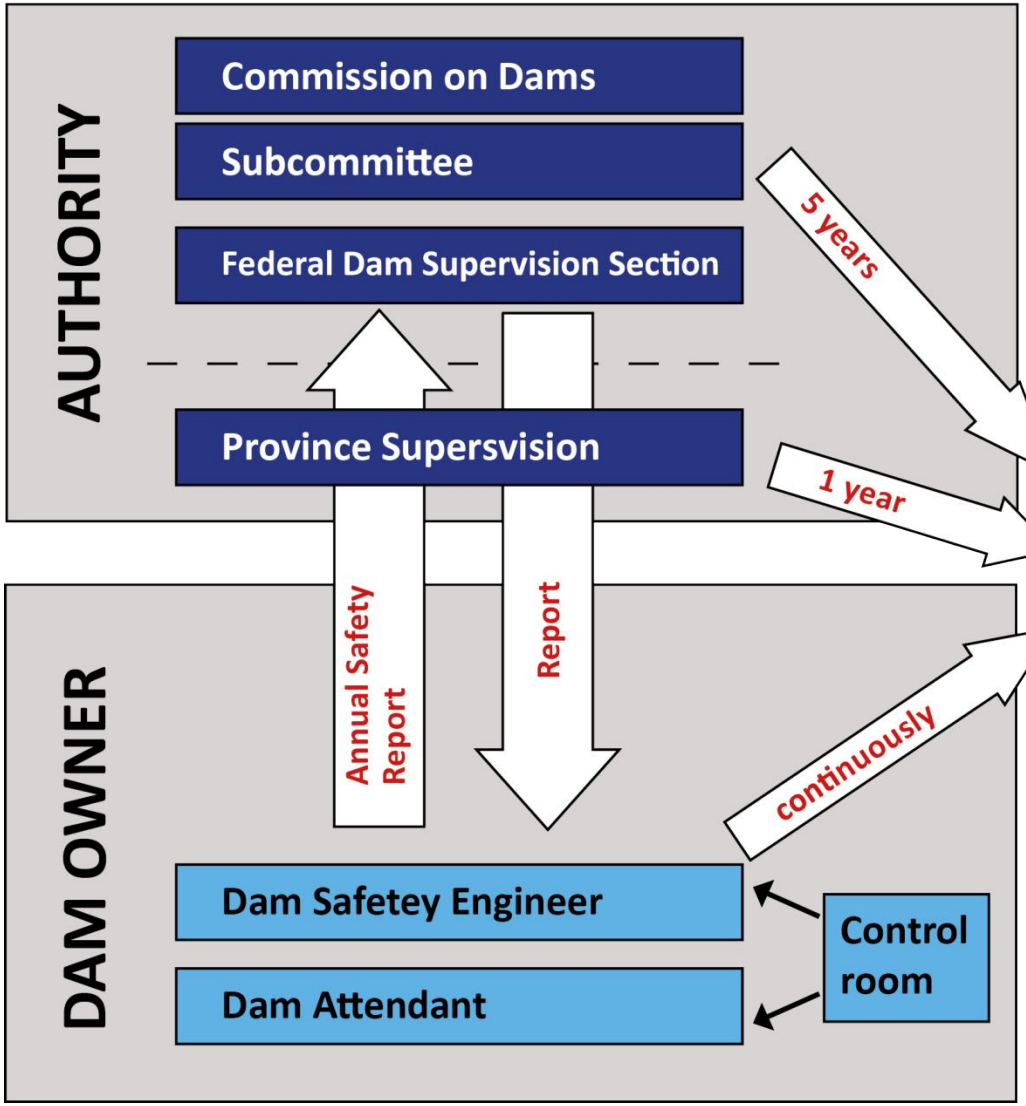


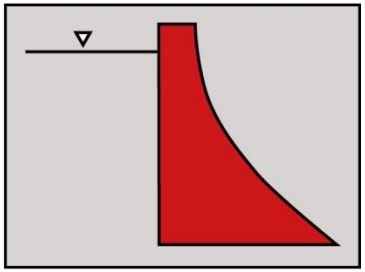
Guideline
stability evaluation
embankment dams


Guideline
flood estimation
safe flood control

Guideline
control centers
supervising
remote controlling

# 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

# Flood Events – Mitigation Measures








Development of Strategies to optimize flood risk management in Styria

Wasserwirtschaft, Ressourcen und Nachhaltigkeit
Amt der steiermärkischen Landesregierung



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

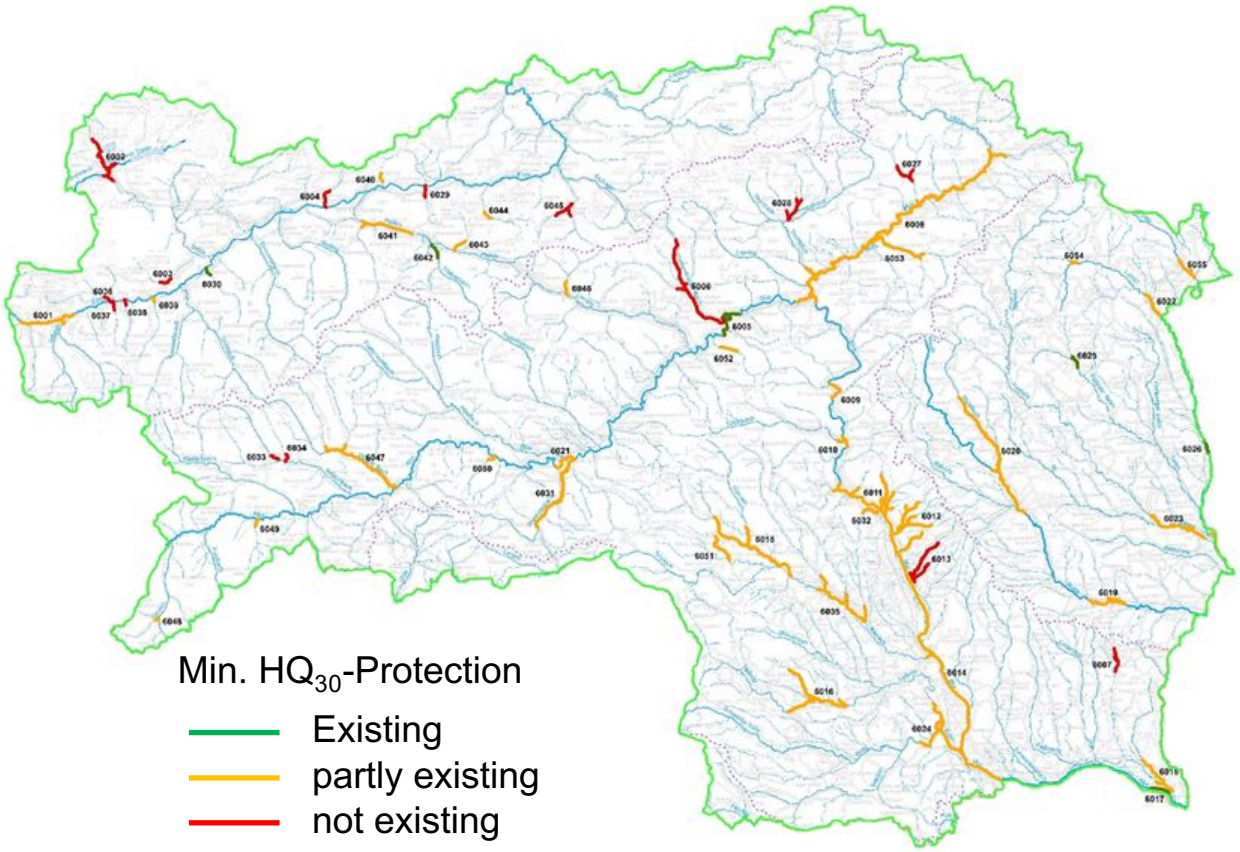
# Areas with Potential Significant Flood Risk

Intermediate Flood Risk Assessment - 2011 (acc. Article 5, EU HWRL)

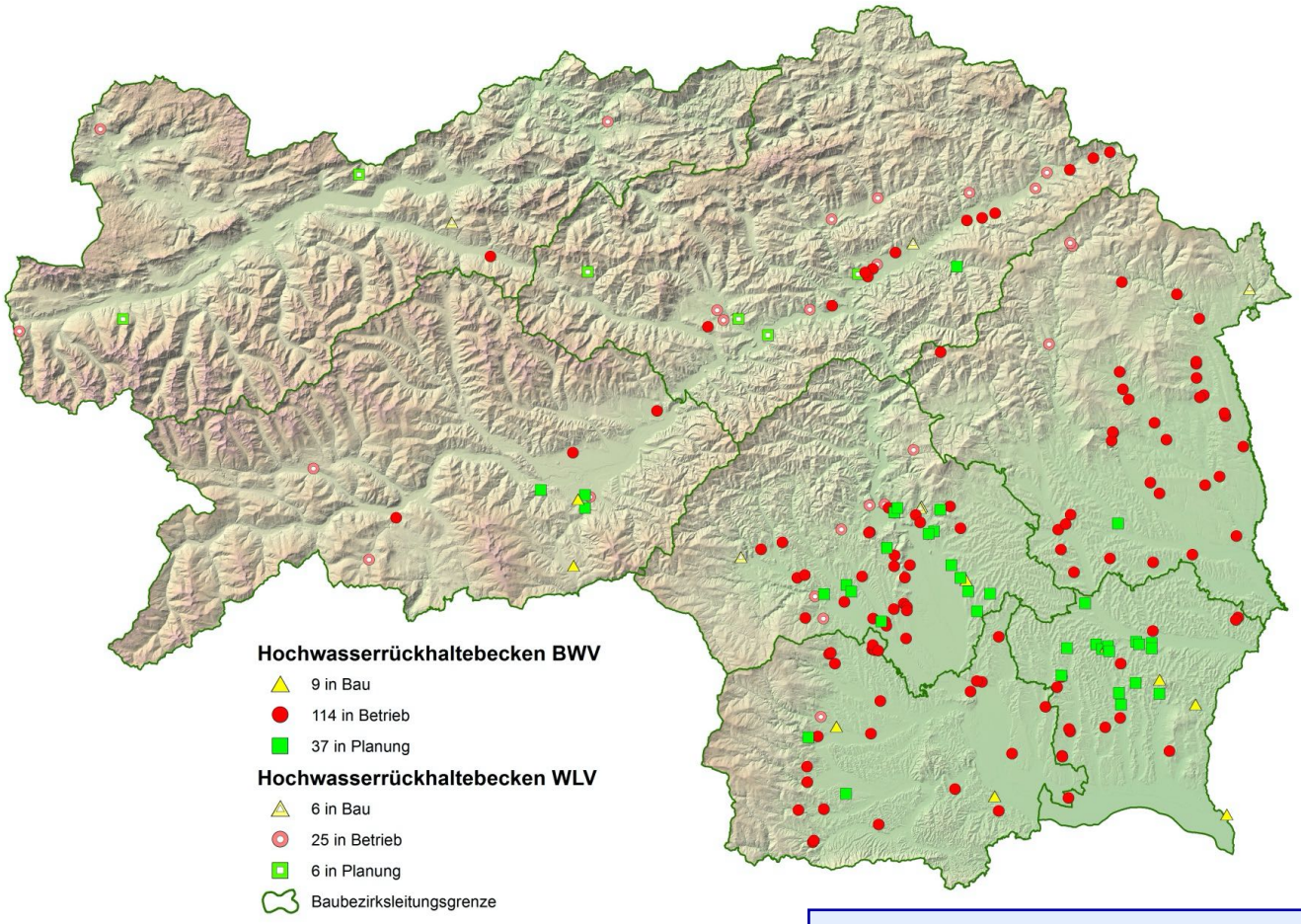
55 APSFR

(Areas with potential significant flood risk)

Length: ~ 525 km




Quelle Abb.: Vorläufige Bewertung des Hochwasserrisikos 2011, www.bmlfuw.gv.at (Stand 06.05.2014)




**1990: 24 RHB - Retention app. 4,4 Mio $m^3$**

**1999: 70 RHB - Retention app. 9,0 Mio $m^3$**

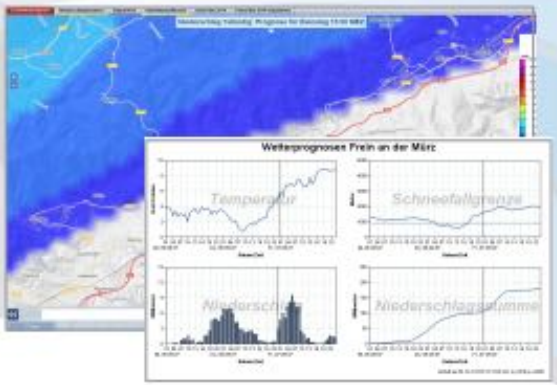
**2015: 114 RHB - Retention app. 15,0 Mio $m^3$**

**Presentation: P.Paar / R.Hornich**

# Research - EFFORS – **E**nhanced **F**lood **For**ecasting

## Starkregen

Zeitlich und räumlich hoch aufgelöste Niederschlags-vorhersage

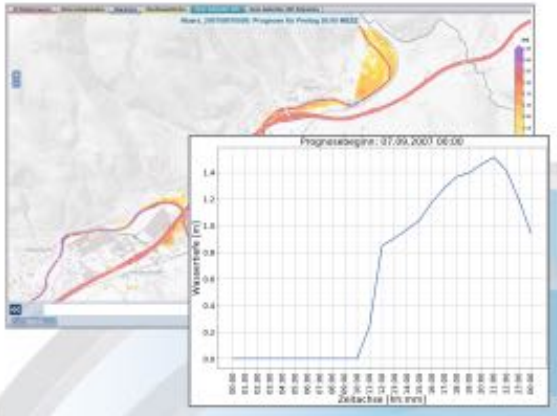



## Durchfluss

Durchflussganglinie für die nächsten 24 Stunden an beliebigen Punkten im Flusslauf


## Überflutungsflächen

Echtzeitsimulation von Hochwasser-überflutungsflächen, Wassertiefen und Fließgeschwindigkeiten an beliebigen Punkten Ihrer Wahl



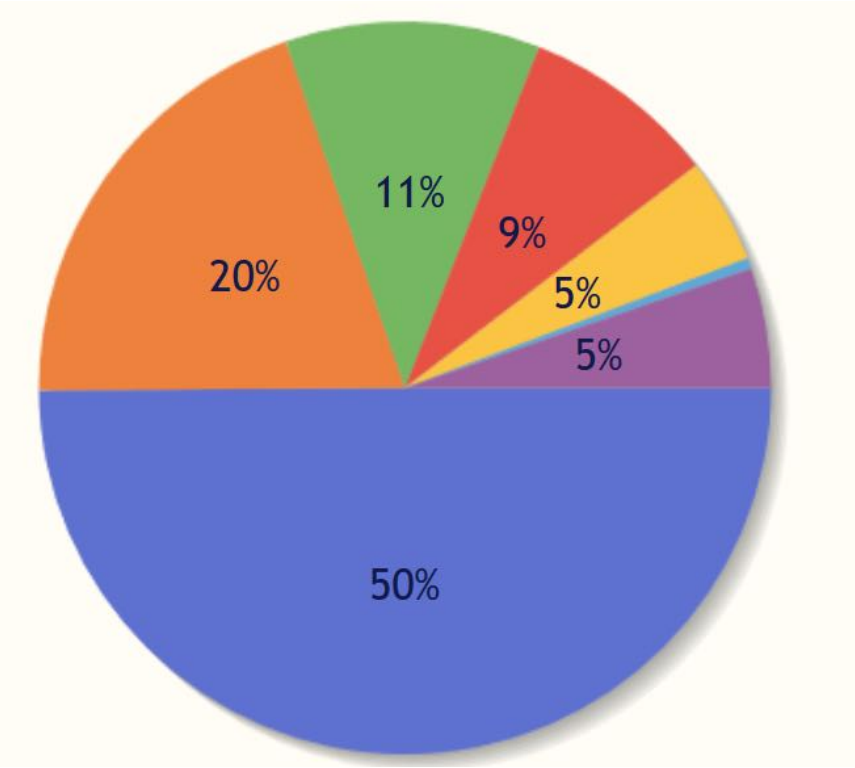
Service für eine 24h-Echtzeit-Vorhersage von:

Meteorologie | Hydrologie | Hydrodynamik

# 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

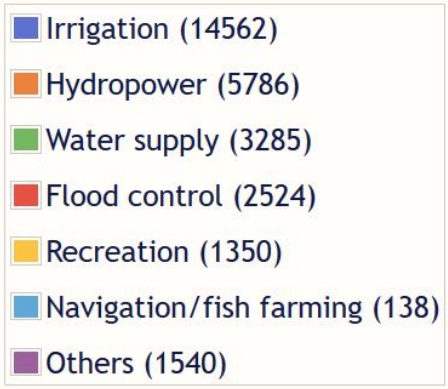
# International Aspect - World Wide ~ 60000 Large Dams



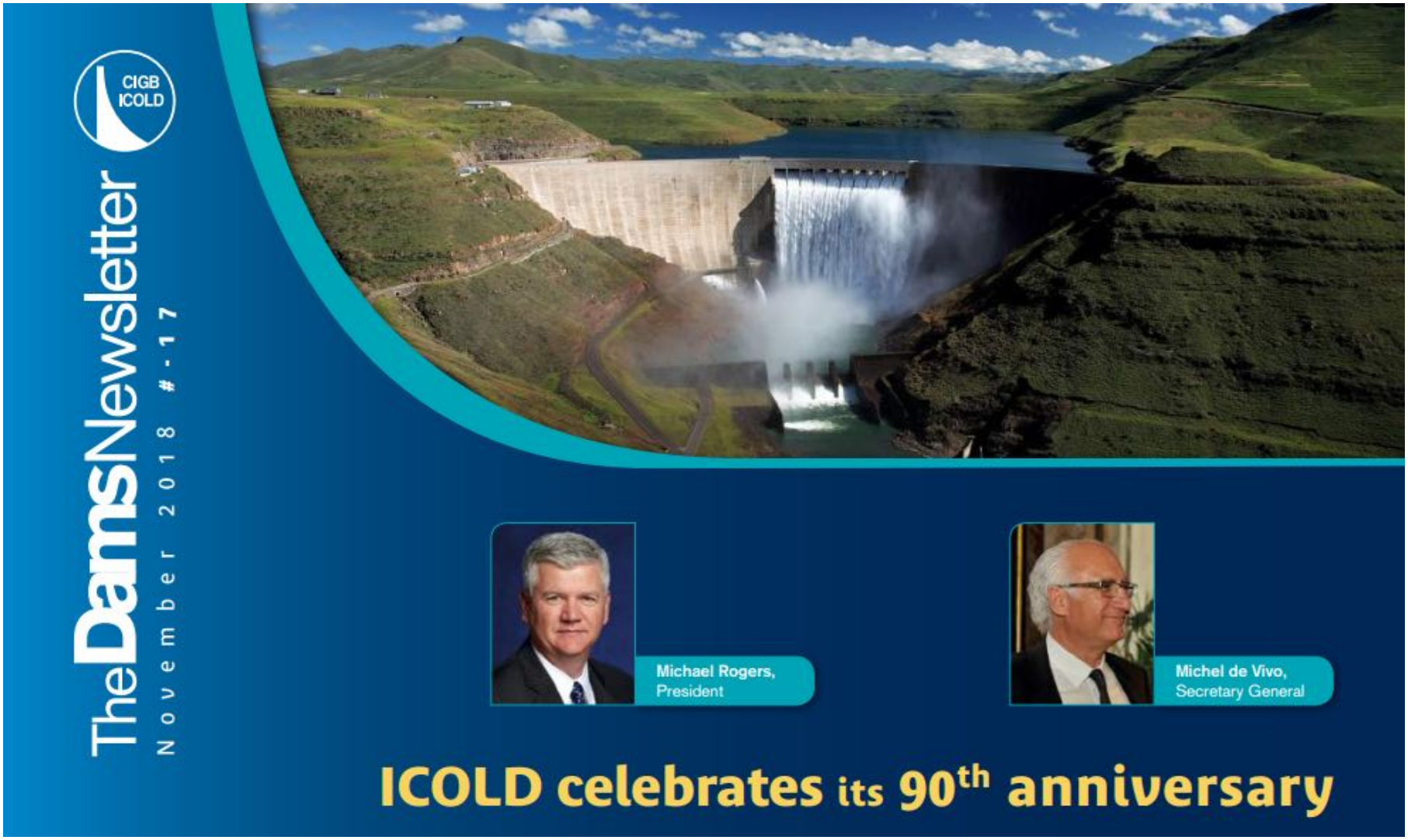

Single Purpose Dams ~ 30000

50% Irrigation

20% Hydro Power




Source: ICOLD https://www.icold-cigb.org/GB/world_register/general_synthesis.asp


CIGB
ICOLD
The Dams Newsletter
November 2018 #-17
Michael Rogers,
President
Michel de Vivo,
Secretary General
ICOLD celebrates its 90th anniversary

# ICOLD Technical Committees

**Committee Workshops increase our communications and input from National Committees, as well as collaboration between Committees**

| | |
|---|---|
| A | Computational Aspects of Analysis and Design of Dams |
| B | Seismic Aspects of Dam Design |
| C | Hydraulics for Dams |
| D | Concrete Dams |
| E | Embankment Dams |
| F | Engineering Activities with the Planning Process for Water Resources Projects |
| G | Environment |
| H | Dam Safety |
| I | Public Safety Around Dams |
| J | Sedimentation of Reservoirs |
| K | Integrated Operation of Hydropower Stations and Reservoirs |
| L | Tailings Dams and Waste Lagoons |
| LE | Levees |
| M | Operation, Maintenance and Rehabilitation of Dams |
| N | Public Awareness and Education |
| O | World Register of Dams and Documentation |
| P | Cemented Material Dams |
| Q | Dams Surveillance |
| RE | Resettlement Due to Reservoirs |
| S | Flood Evaluation and Dam Safety |
| T | Prospective and New Challenge for Dams and Reservoirs in the 21st Century |
| U | Dams and River Basin Management |
| V | Hydromechanical Equipment |
| W | Selection of Dam Type |
| Y | Climate Change |
| Z | Capacity Building and Dams |

Pic.: ICOLD

**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

ICOLD
International
Commission on
Large Dams

# 15th International Benchmark Workshop on Numerical Analysis of Dams

9th - 11th September 2019
Milano, Italy

**Topics**

**Theme A:** **Seismic analysis of Pine Flat concrete dam.** *Formulators: USBR; University of Boulder (USA). KTH (Sweden). RSE (Italy)*

**Theme B:** **Seismic analyses of Menta Embankment dam.** *Formulators: Cassino and Southern Lazio University; Perugia University; So.Ri.Cal. SpA (Italy)*

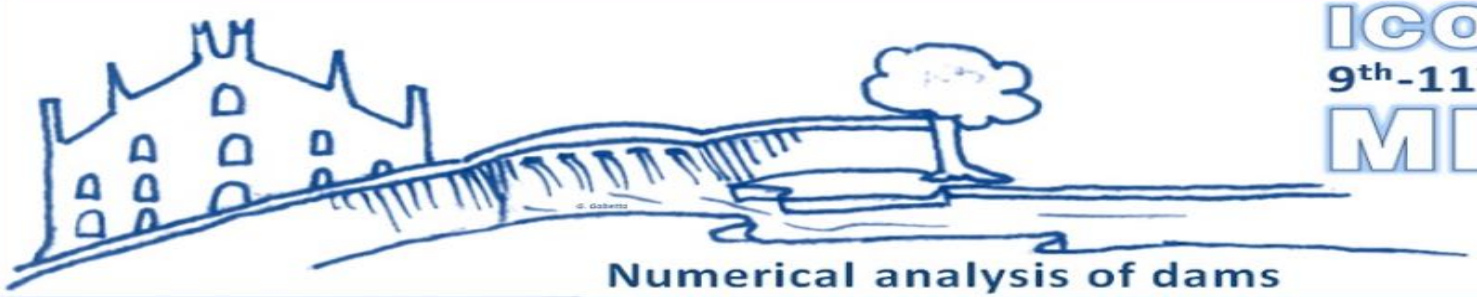
**Theme C:** **Coupled hydromechanical analysis of the pre-failure and the failure behaviour of a levee on soft subsoil.** *Formulators: Politecnico di Milano (Italy). Delft University of Technology; STOWA (The Netherlands)*

**Open Theme:** Papers related to numerical modelling of dams and/or appurtenant structures

| | |
|---|---|
| 1991 | Bergamo, Italy |
| 1992 | Bergamo, Italy |
| 1994 | Paris, France |
| 1996 | Madrid, Spain |
| 1999 | Denver, United States |
| 2001 | Salzburg, Austria |
| 2003 | Bucharest, Romania |
| 2005 | Wuhan, China |
| 2007 | St. Petersburg, Russia |
| 2009 | Paris, France |
| 2011 | Valencia, Spain |
| 2013 | Graz, Austria |
| 2015 | Lausanne, Swiss |
| 2017 | Stockholm, Sweden |
| 2019 | Milano, Italy |

POLITECNICO MILANO 1863 METID

CONFERENCE HOME ABOUT SEARCH TEAM VENU




ICOLD-BW 2019
9th-11th September
MILANO

2018

# Workshop of ICOLD Technical Committee on *Computational Aspects of Dam Analysis and Design*

## 30 years of activity

**Guido MAZZA**




2021

## 16th Benchmark Workshop - Ljubljana

# Dam Safety

## VP Michel Lino

world hydropower congress

## 2017-2019 : a bad series

Feb 2017 : Oroville (USA)

May 2018 : Ituango (Colombia)

May 2018 : Patel (Kenya)

June 2018 : Xe Namnoy (Laos)

Aug 2018 : Swar Shaum (Myamar)

Jan 2019 : Brunadinho (Brazil)


# 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.

Austrian National Committee on Large Dams

2nd Experts Seminar

KAPRUN, Province of Salzburg
AUSTRIA

# Dam Surveillance Practice

# Research and Future Needs

Selection of Dam Type

- CFRD – Fill dam with concrete surface sealing
- RCC – Gravity dam with continuous concrete placement
- New Materials
- Optimization of Geometry – Digitalization – Numerical Models

Design Criteria – Regulations – ICOLD Bulletins

Surveillance – Maintenance – Renewal Licence – Long term performance

Interaction – Water – Structure – Flexibility - Strength

Numerical Methods play a significant role – ICOLD Benchmarks

Organizations

- National Committee‘s on Large Dams
- ICOLD – International Commission on Large Dams
- Knowledge Transfer

**D**o be

**A**ware of

**M**ultiple benefits &

**S**ustainable effects