14 September 2017, SoE Annual Conference 2017

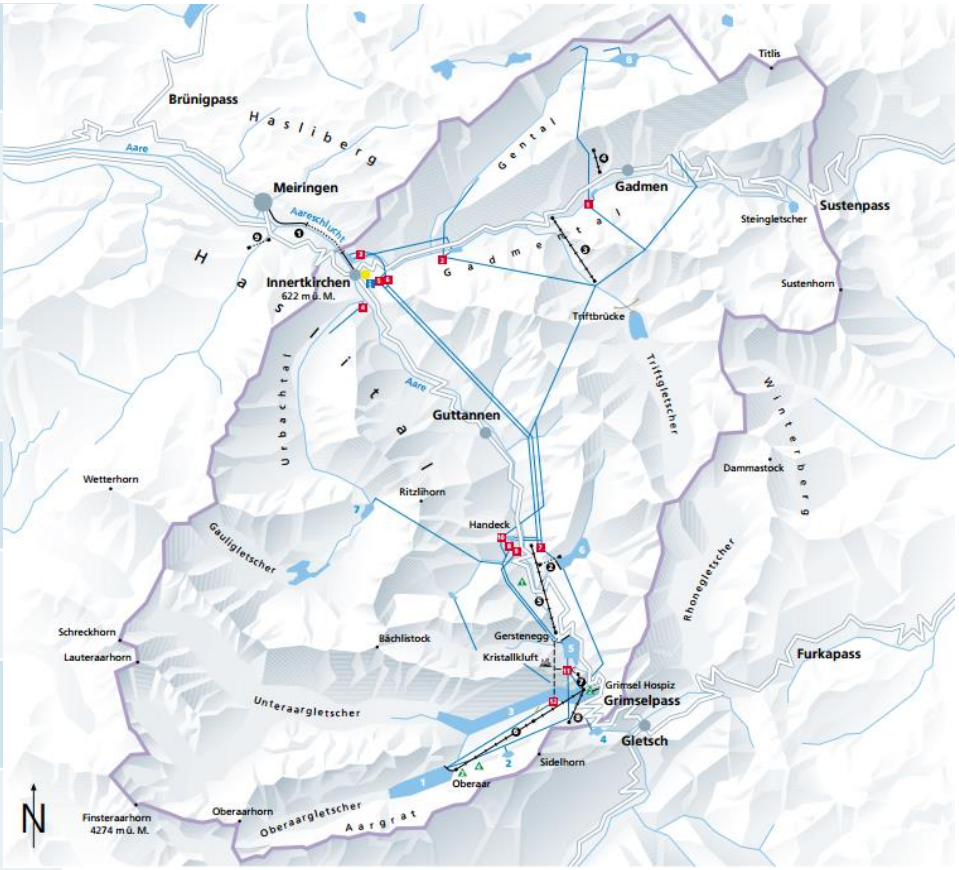
Hydropower: View from the Industry

Daniel Fischlin

CEO

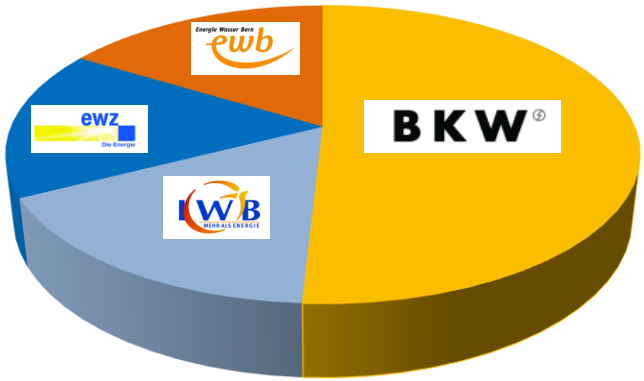
Key data of KWO

 Employees therefrom apprentices	318 full-time jobs 23
 Annual production	2'130 GWh (2016)
 Annual inflow	800 Mio. m³
 Annual turnover	CHF 140 Mio.
 Storage capacity	195 Mio. m³ 8 storage lakes
 Installed capacity	1'317 MW
 Power plants	10
 Catchment area	420 km²



Shareholders of KWO

- BKW Energie AG, ½
- Energie Wasser Bern, ⅙
- Industrielle Werke Basel, ⅙
- Stadt Zürich, ⅙



Thoughts on the future development

Questions to be reflected

- How the power plant park will develop in the surrounding countries?
- Which storage technology will prevail and in what time frame?
- Will the "energy only" market continue to exist?
- What influence will the abandonment of nuclear energy 2022 in Germany have on the prices?
- Are the empty storage lakes during the winters 2015 and 2016 an indication of a long-term trend?

Production costs of all joint ventures

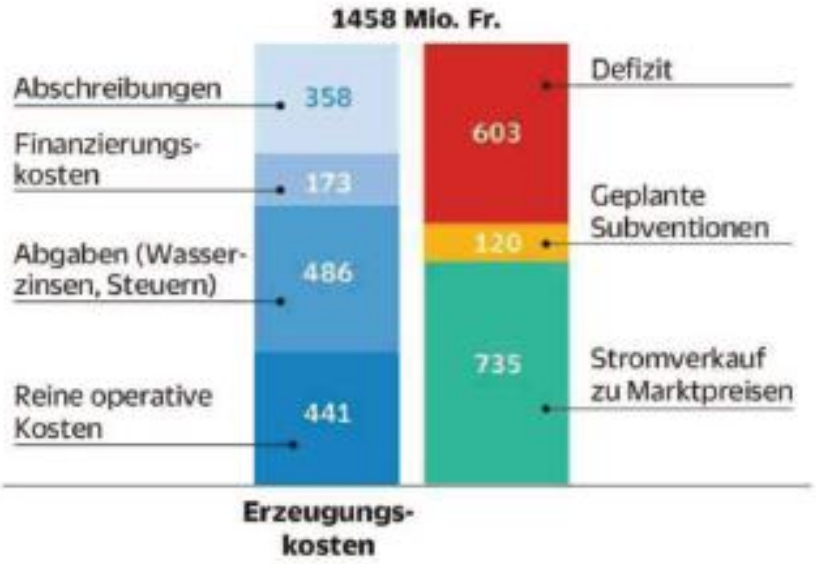
Unter der Schmerzgrenze

Entwicklung der Grosshandelspreise in Deutschland

Quelle: Thomson Reuters, Independent Credit View

Drohende Millionenverluste

Prognostizierte jährliche Defizite der Schweizer Wasserkraftwerke



Quelle: Independent Credit View, UREK-N

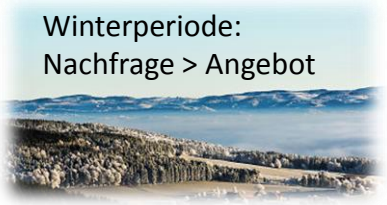
Quelle: NZZ am Sonntag, 22.05.2016

Developments in the European electricity market

- **Decommissioning of generation capacities** in Europe and Switzerland:
  - nuclear power phase-out 2022 in Germany (**-10.8 GW** inst. capacity; total 20.9 GW)
  - deactivation NPP Mühleberg in Switzerland (**-373 MW** inst. capacity)?
  - deactivation NPP Beznau 1 in Switzerland (**-365 MW** inst. capacity)?

- **More expected breakdowns** of aging NPP`s in France
- **Delay in the construction** of the HVDC transmission line from the north to the south in Germany
  → Excessive production in the north cannot be transmitted to the southern part of Germany

- **Winter period:** Increasing demand for power output and storage capacity
  → The gap caused by energy from wind and solar sources can be closed by hydro production, primarily by storage power plants

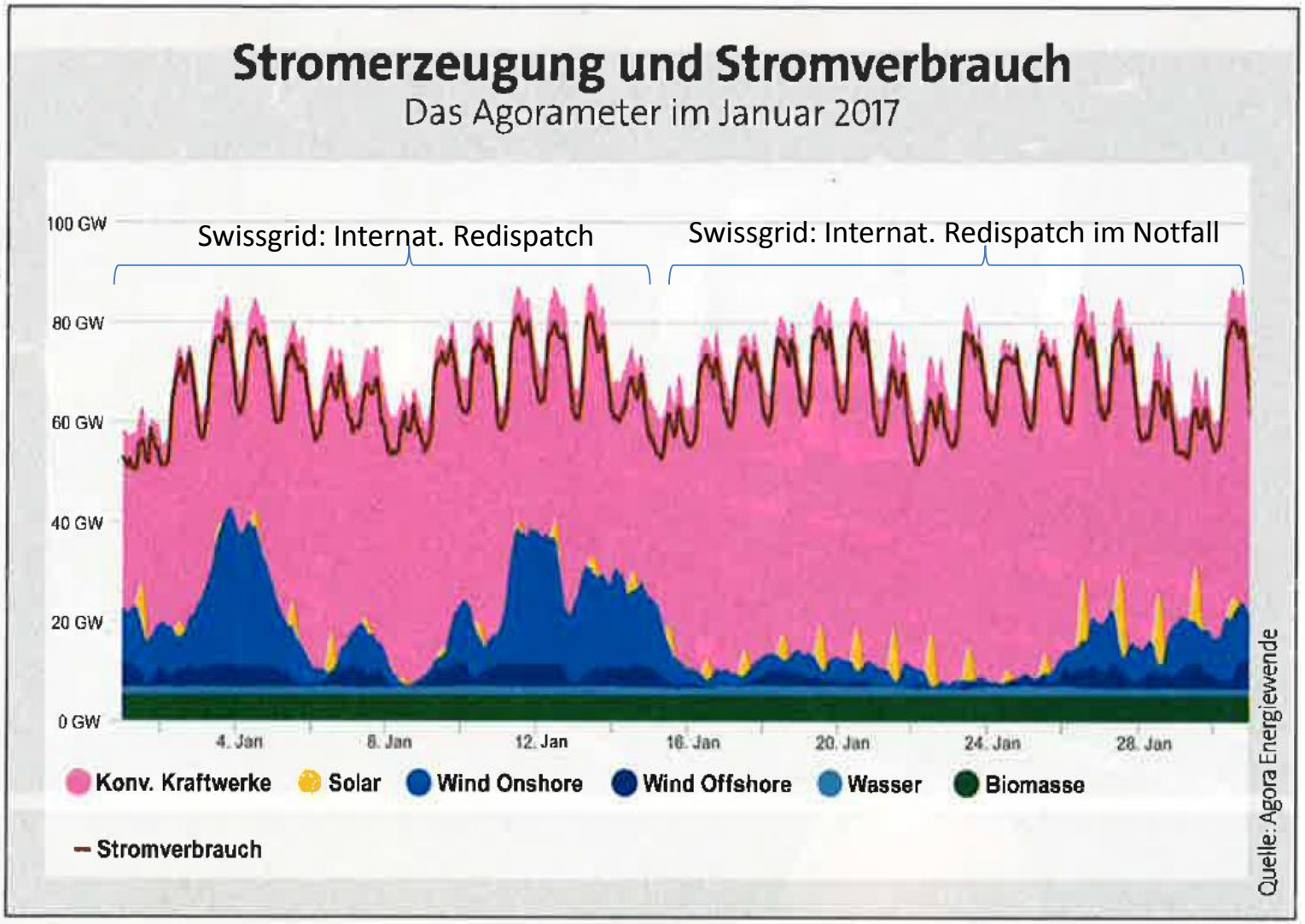


Prepared for the future:

KWO is able to supply the demand thanks to the expansion projects:

✓ New storage lake Trift, new power plant Trift
✓ Enlargement of Lake Grimsel
✓ New Pump Storage Plant Grimsel 1E

Situation in Germany January 2017



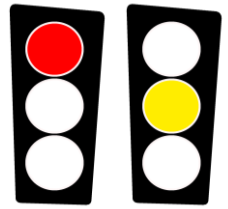
Impacts on grid stability

December 2016

- Power production in CH is not sufficient. Duty cycle of imports: 94 %
- **18** frequency deviations +/- 100 mHz
- **22** French NPP`s out of order
- Risk of cascading outages in certain regions
- The international warning system RAAS has been placed on amber alert 10 times.
- International redispatches: in emergency operations the TSO`s help each other across borders to stabilise the power grid

Januar 2017

- Power production in CH is not sufficient. Duty cycle of imports: 98 %
- **28** frequency deviations +/- 100 mHz
- **6** French NPP`s out of order
- Warning system **20x** on amber alert and **1x** on **red alert** (close to a blackout)
- Redispatch Swissgrid for the European power grid only in absolute emergency, because the reserves in the storage lakes were too low.



→ **KWO empty the lake Oberaar to support the power grid**

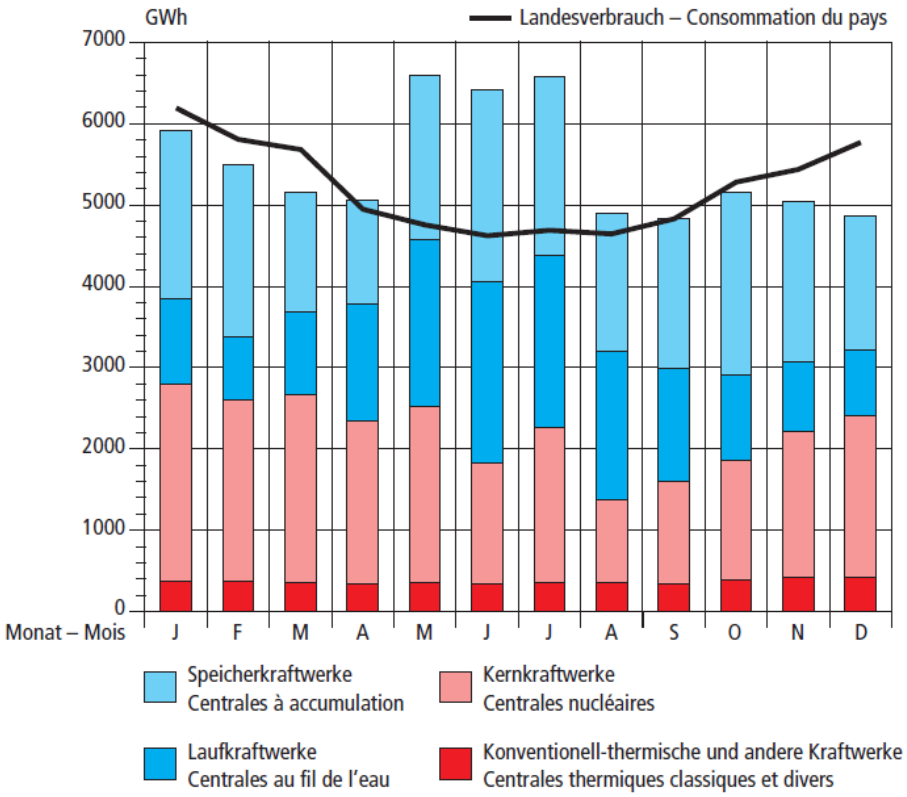
KWO`s contribution to grid stability January 2017

Result: Lake Oberaar was empty!

Quelle: KWO

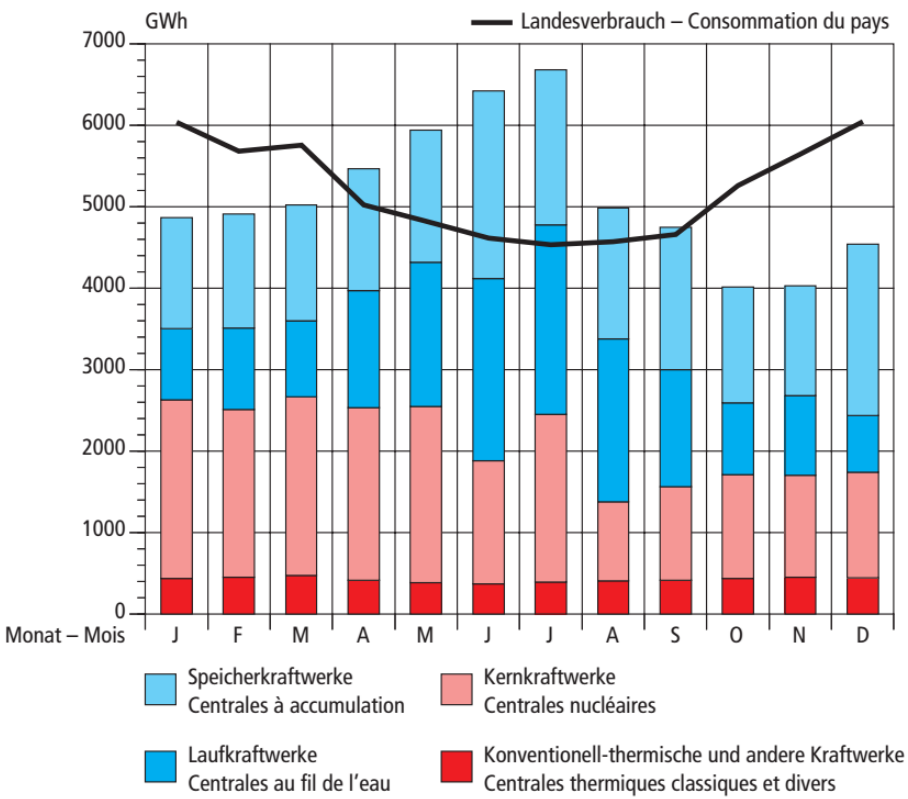
Annual production in Switzerland

2015



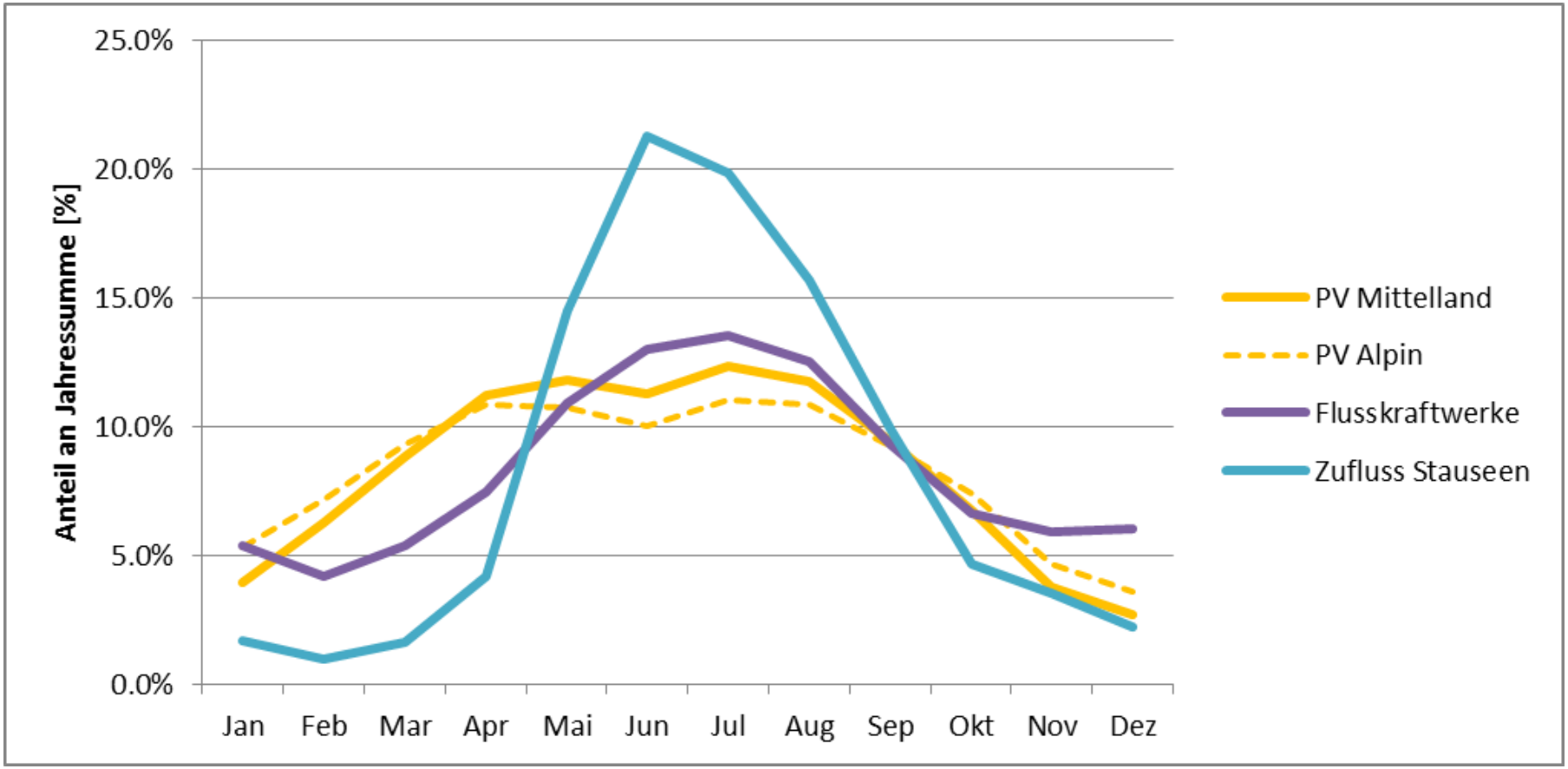
Quelle: BFE Elektrizitätsstatistik 2015

2016



Quelle: BFE Elektrizitätsstatistik 2016

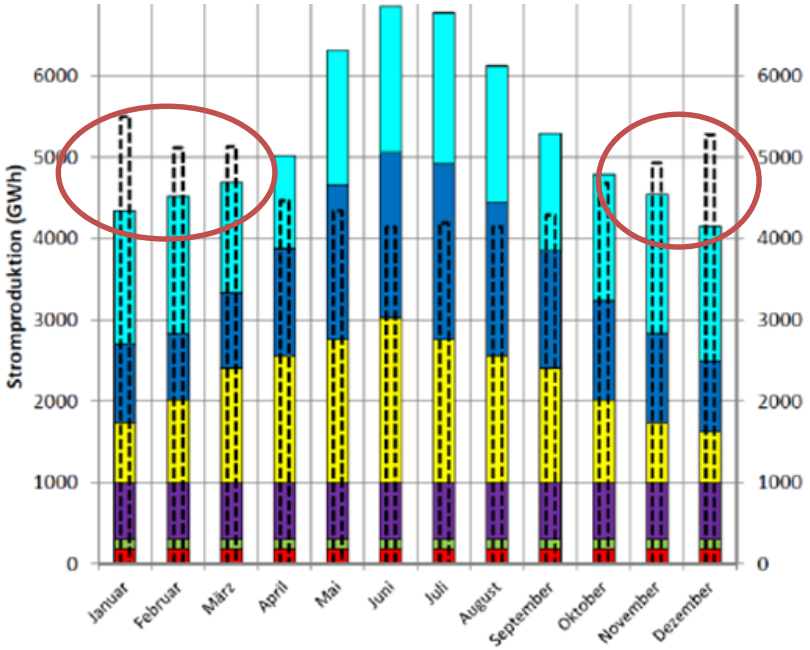
Production cycles renewable sources



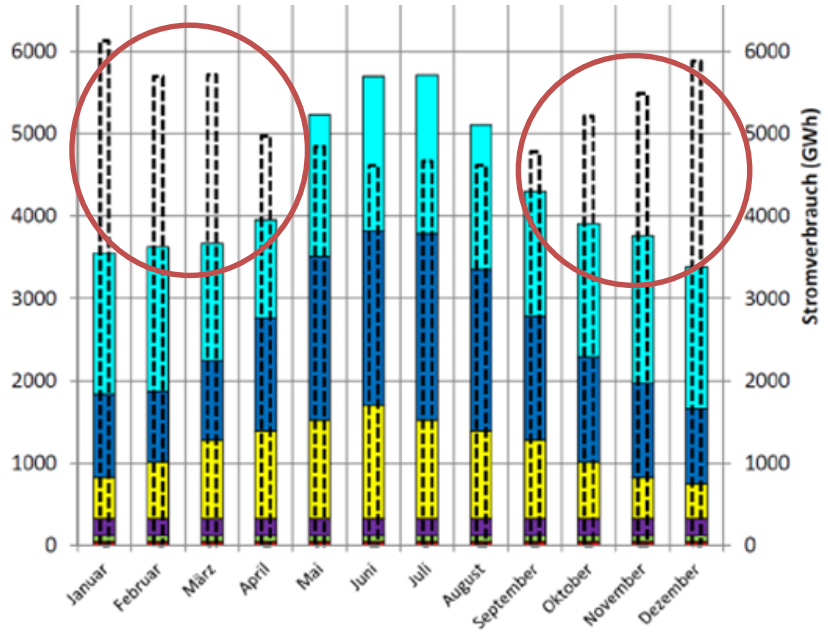
Quelle: BFE und Meteotest, Jahre 2008-2011

Two scenarios 2035 without NPP`s

Scenario environmental alliance



Scenario BFE energy strategy



Forecast electricity generation

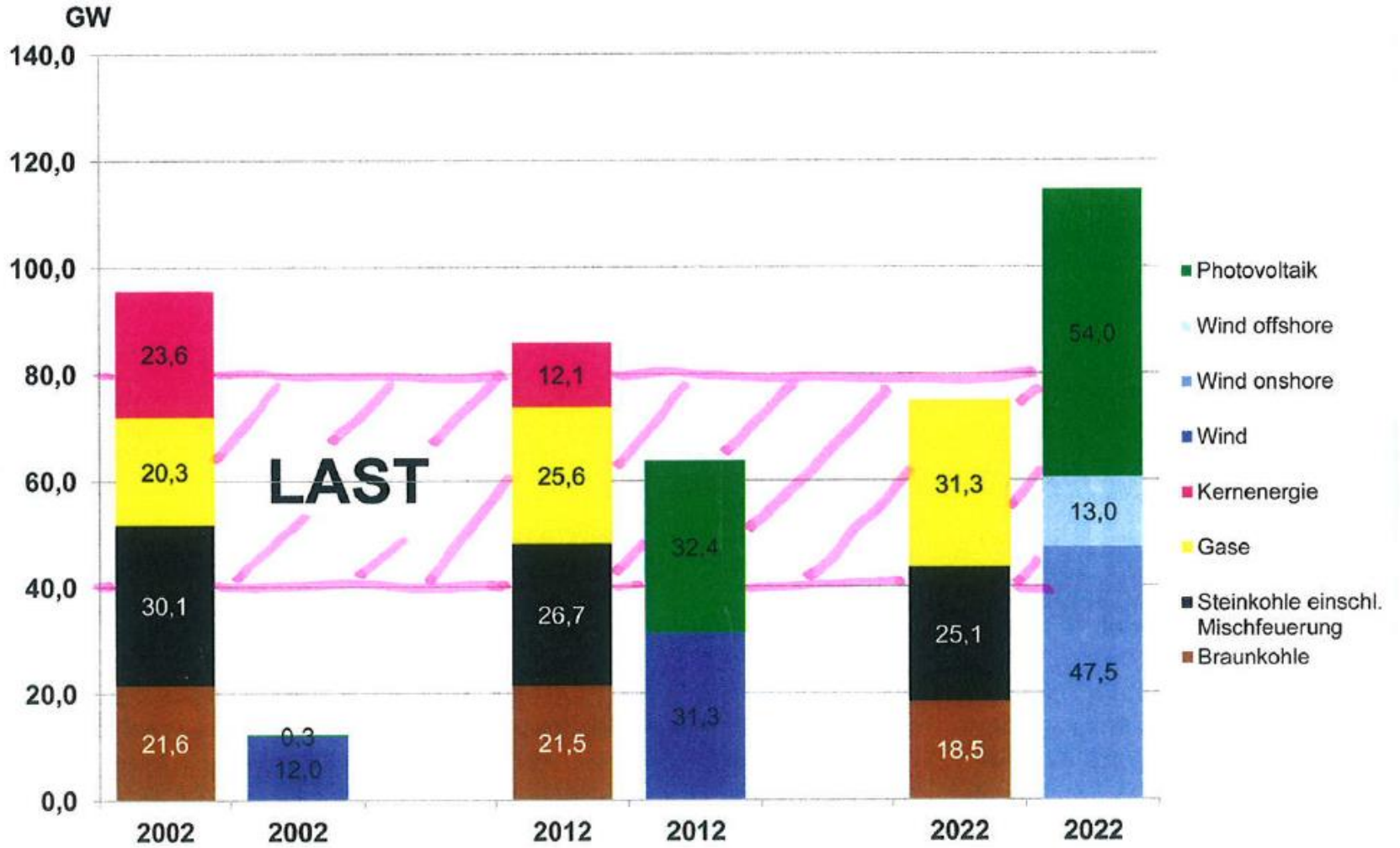
- storage hydropower
- run-of-the-river hydropower
- photovoltaics
- wind
- biomass
- thermal power plants

Forecast demand

- consumption
- deficit

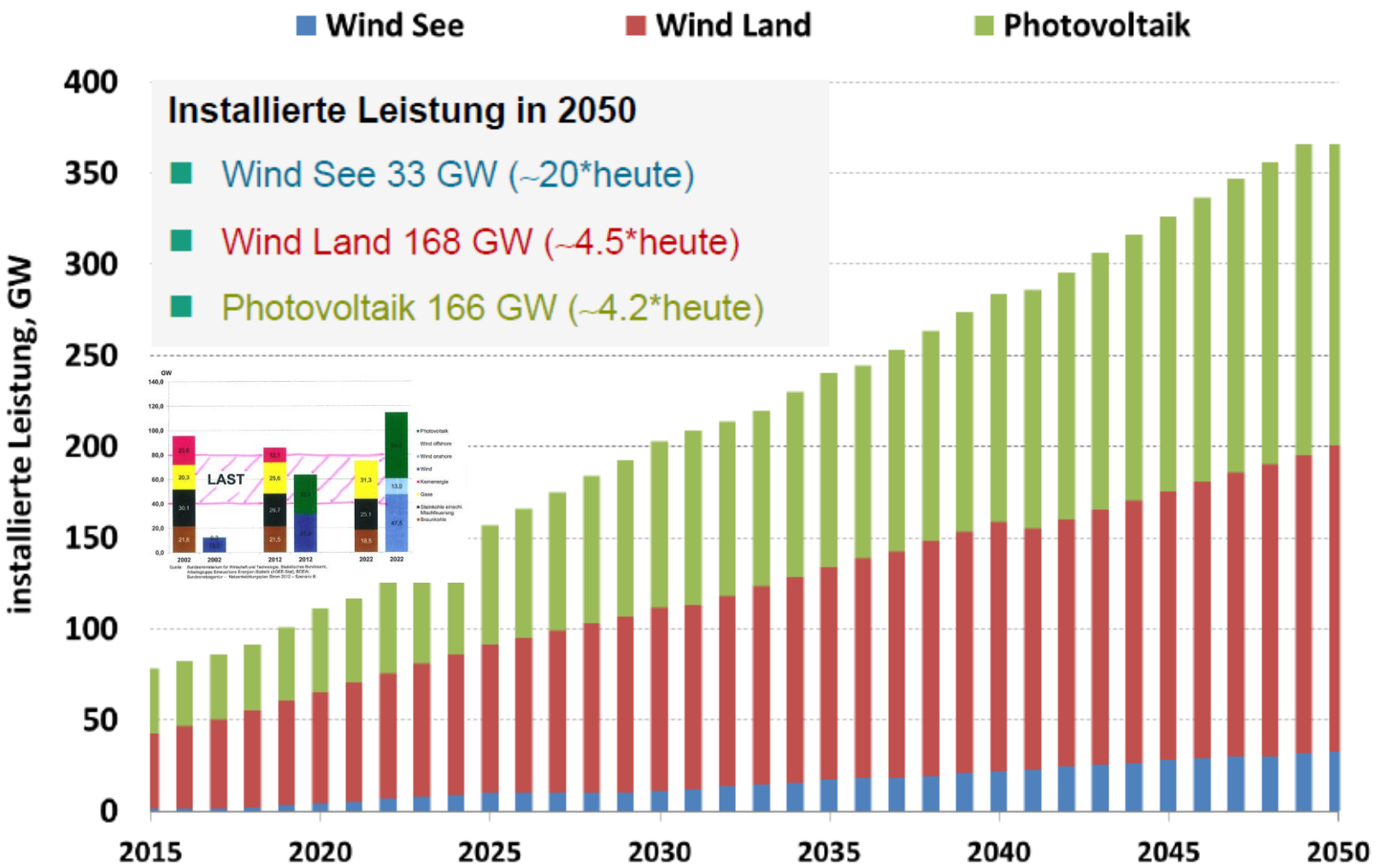
→ Both scenarios forecast a lack of power

Installed capacity in Germany



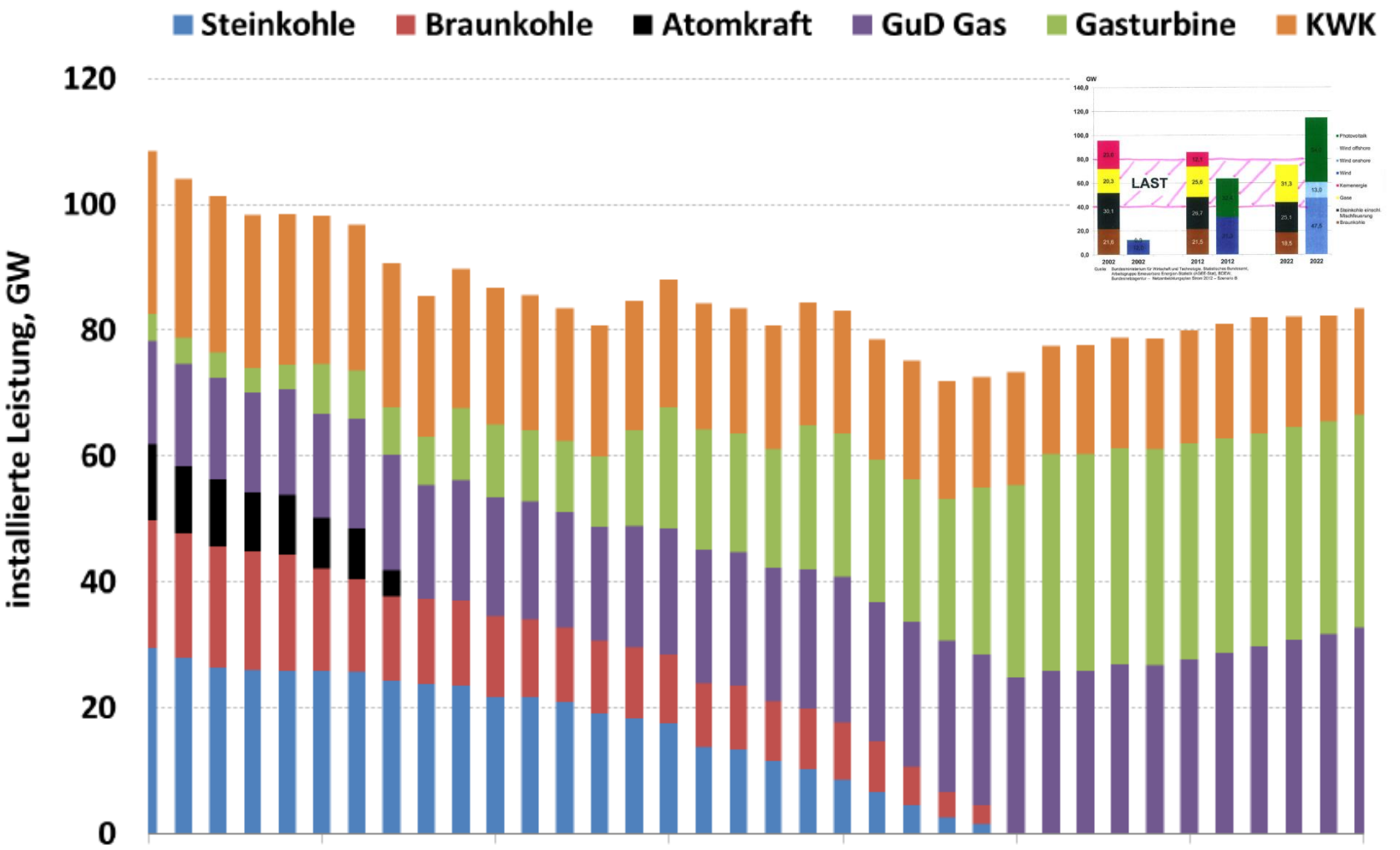
Quelle: Bundesministerium für Wirtschaft und Technologie, Statistisches Bundesamt, Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat), BDEW, Bundesnetzagentur – Netzentwicklungsplan Strom 2012 – Szenario B

Forecasted capacity in Germany



Quelle: Frauenhofer ISE, 2016

Development of the power plant park in Germany



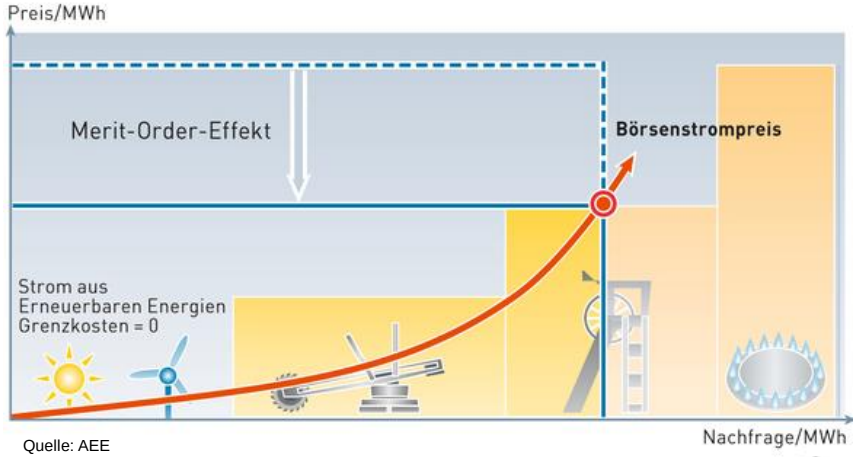
Quelle: Frauenhofer ISE, 2016

Electricity market and pricing

present time

- Base for today's electricity price: **marginal costs**
- Market distortion energy from wind and sun
  → variable costs decrease to zero
  → subsidised by the state
- Conventional power plants are **"gap fillers"**
- Loss-making power plants:
  ↘ operating hours ↗ uncovered costs
- Power plants **free of charge** in stand-by mode
  → only sold energy is paid

Der strompreisdämpfende Effekt der Erneuerbaren Energien (Merit-Order-Effekt) senkt den Börsenstrompreis



Quelle: AEE

future

- Another pricing model?
- Provision of capacities will be compensated?
- Electrical energy more favourably priced, on the other hand rising grid costs?
- Producers can charge higher prices during peak loads?

Quelle: BEE/Greenpeace energy/IZES

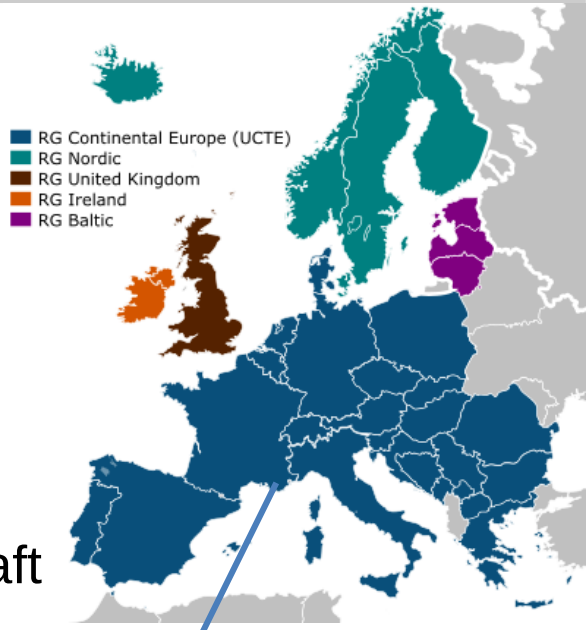
Grid inertia due to rotating masses

Questions to be reflected

- What is the influence on grid stability by decreasing inertia masses?
- What is the time frame for "electronic inertia" to achieve industrial maturity?

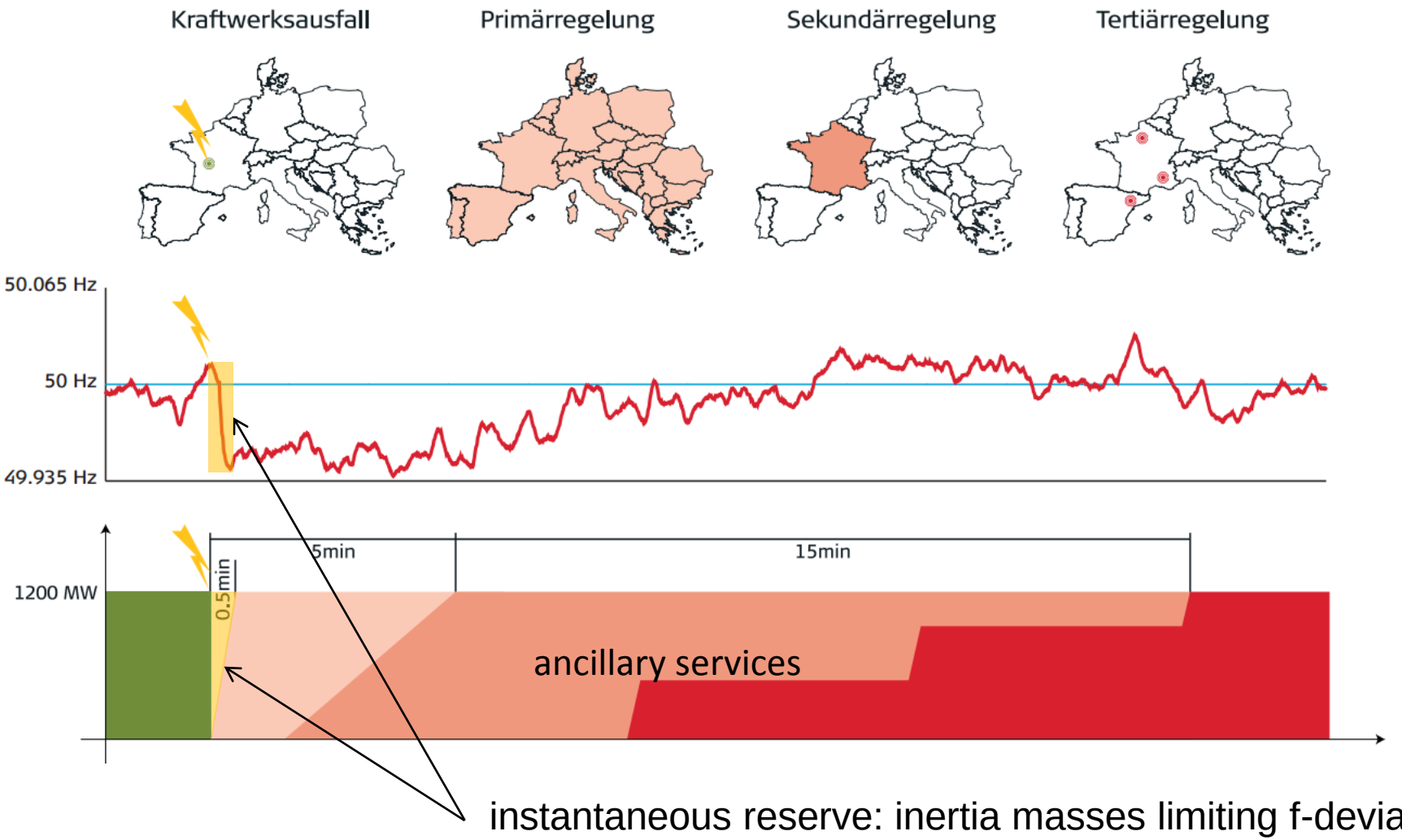
Model of the Central European power grid

- Rotating shaft, which turns at a rate of 50 rotations per second
- All producers und consumers coupled by a shaft
- Producers accelerate, consumers decelerate the shaft
- Production ≠ consumption → speed change

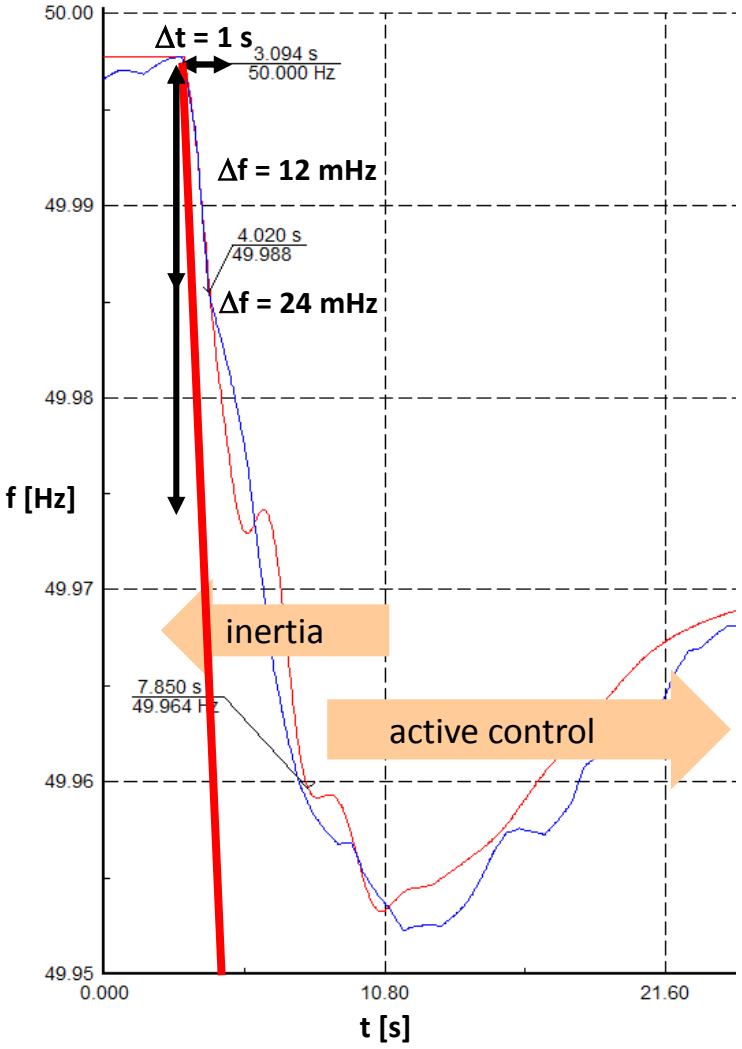


n=3000 u/min

Offers of ancillary services



Influence on grid stability by inertia masses



02.04.2003 - AKW Paluel (F)

Failure of one 1.2 GW power plant unit

Frequency deviation Δf = -50 mHz

Half inertia masses → Δf = - 100 mHz

The **decrease of inertia masses** leads to an **increased risk** of dangerous frequency drops.

Grids with **less inertia masses react more sensitively** to frequency oscillations

KWO`s current projects

Aspects to be reflected

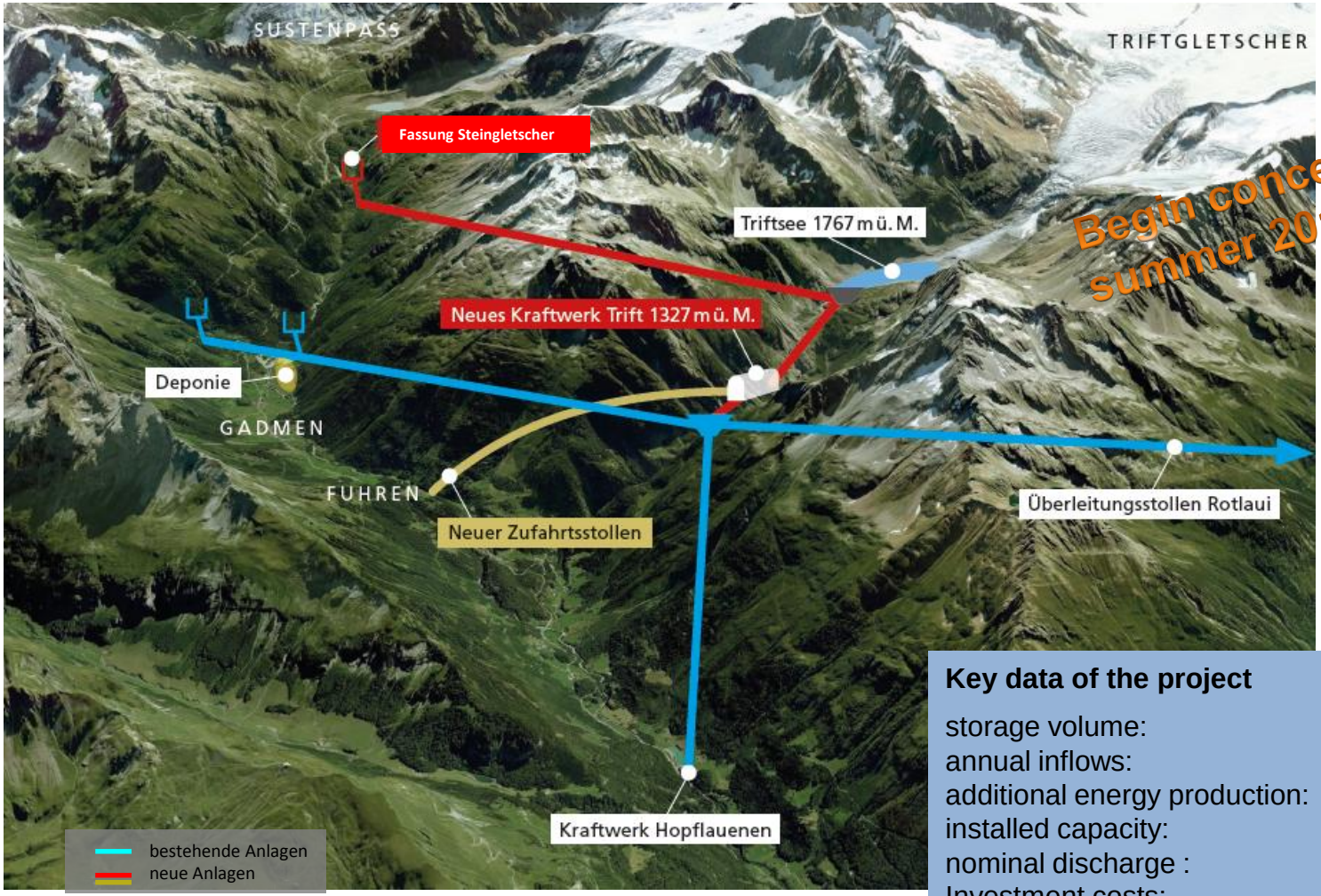
- The increase in photovoltaic capacity causes an over-availability of energy in summer.
- KWO is only able to store 25% of the annual inflow (April-October) and therefore can be transferred to the winter period.
- KWO in function as a "run-of-river power station" does not produce enough revenue during the summer period.
- Sufficient pump-storage capacity in Switzerland for the coming years

=> Safeguarding the future of KWO by means of expanding the storage capacity

Retreat of the Trift glacier

Trift Dam

Storage project Trift – Gadmen valley



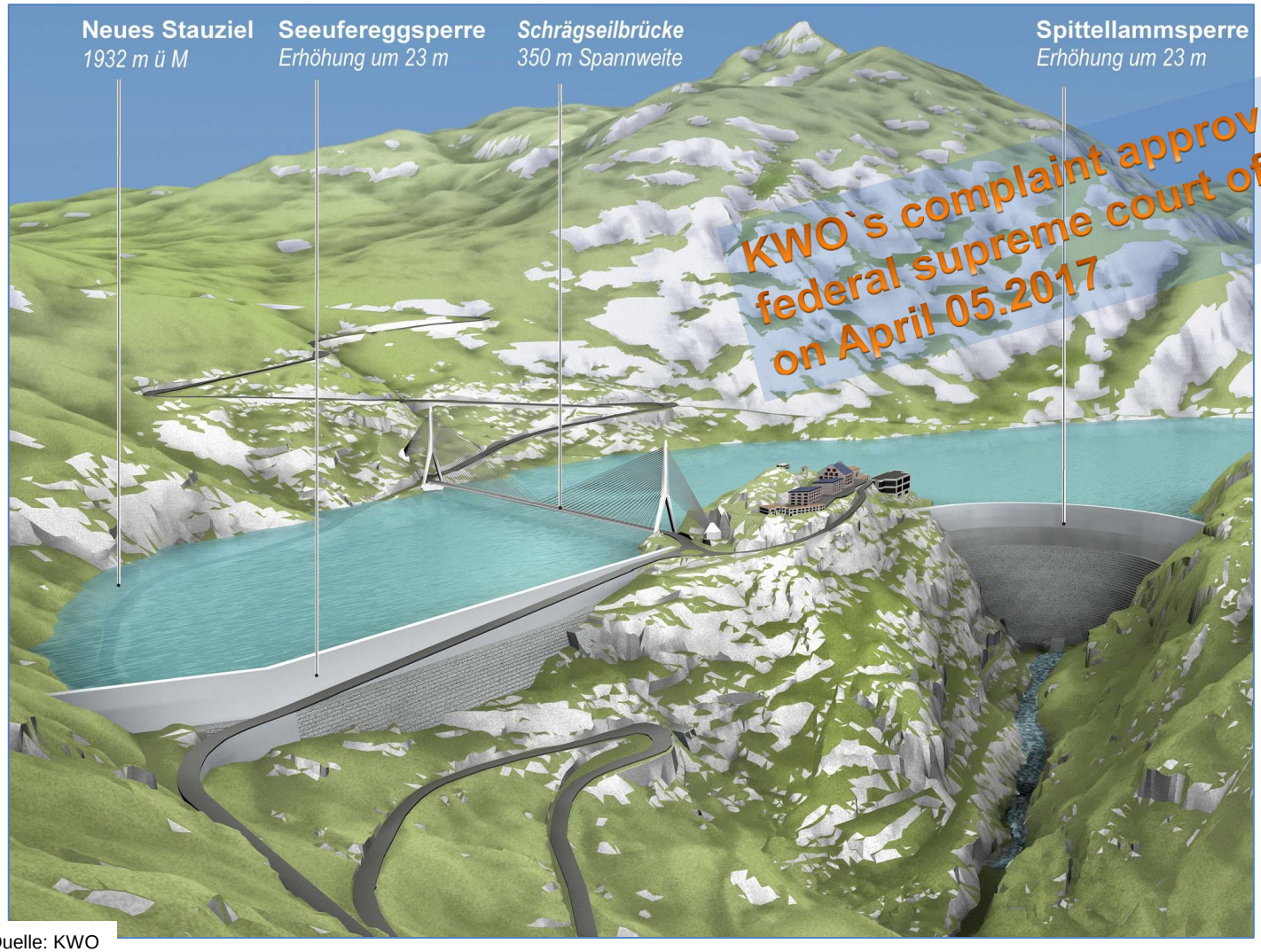
Begin concession process summer 2017

Key data of the project

storage volume:	85 Mio. m^3/ 215 GWh
annual inflows:	154 Mio. m^3/a
additional energy production:	145 GWh/a
installed capacity:	80 MW
nominal discharge :	21 m^3/s
Investment costs:	387 mio.CHF

Quelle: KWO

Storage project Grimsel – Aare valley



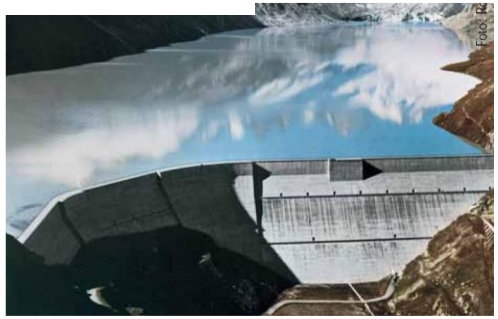
Quelle: KWO

Storage project Grimsel – Aare valley

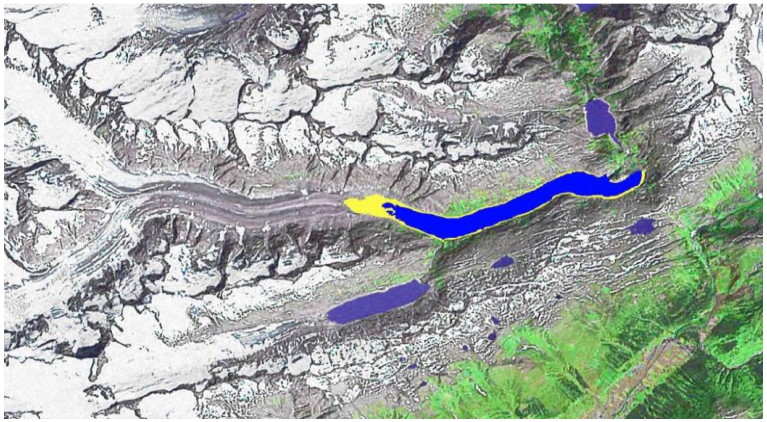
Substantial increase of storage energy throughout Switzerland with take out a low environmental impact

Göscheneralp:
- height: 155 m
- lake's surface: 1.32 km^2
- dam volume: 9.3 Mio m^3
- **energy content : 221 GWh**

Limmern:
- height: 146 m
- lake's surface: 1.36 km^2
- dam volume: 0.6 Mio m^3
- **energy content : 258 GWh**



Oberaar:
- height: 104 m
- lake's surface: 1.46 km^2
- dam volume: 0.45 Mio m^3
- **energy content : 243 GWh**



Increase lake Grimsel:
- additional height: 23 m (present height: 114 m)
- additional lake's surface: 0.8 km^2
- additional dam volume: 0.5 Mio m^3
- **additional energy content: 240 GWh**
- **present energy content: 270 GWh**

Quelle: KWO

New construction of Spitallamm Dam (lake Grimsel) as of 2019

Key data :

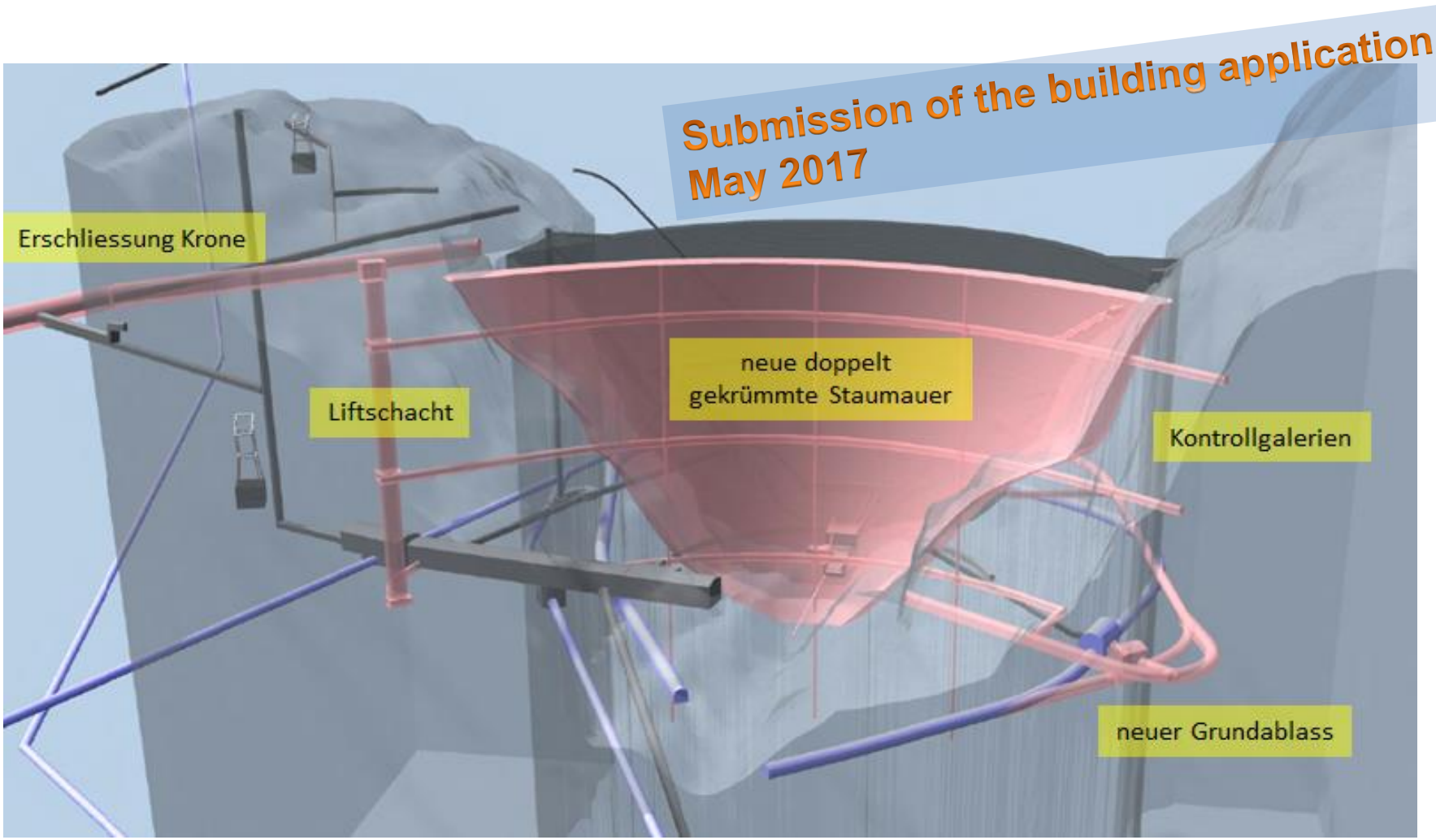
- hight ca. 115 m (without increase)
- volume of concrete ca. 160’000 – 205’000 m3
- construction time ca. 5 – 6 years

Licensing procedure:

- Building consent with environmental compatibility test

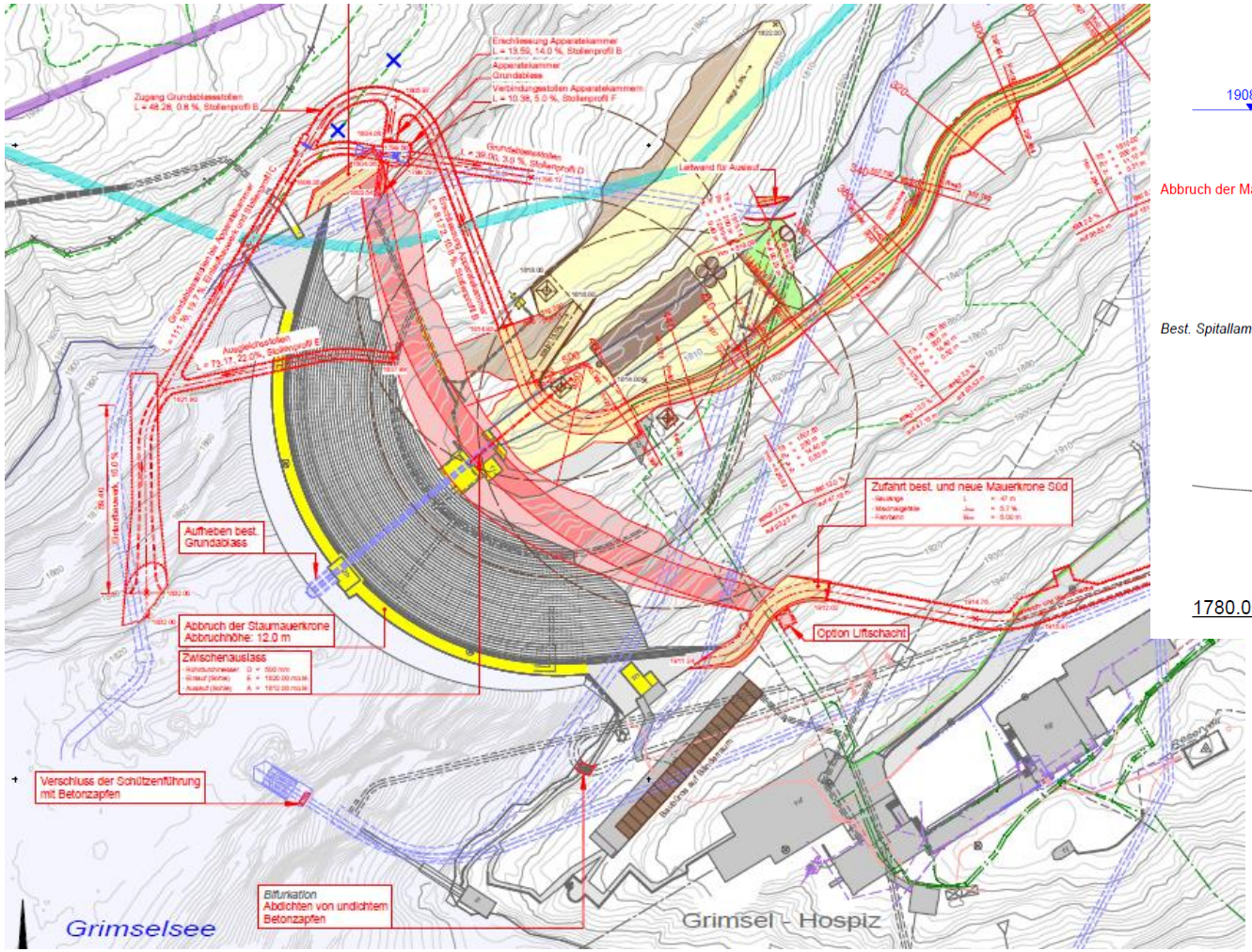
Quelle: KWO

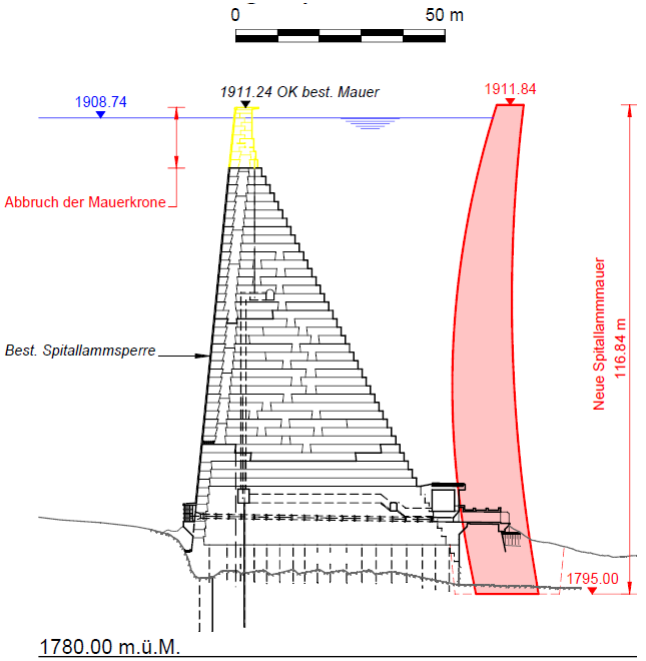
New construction of Spitallamm Dam as of 2019



Quelle: KWO

New construction of Spitallamm Dam as of 2019





Quelle: KWO

View of the new dam

Quelle: KWO

Thank you very much for your interest

HYDROPOWER has good prospects for the future

…and KWO takes on the role of take out the most important player