CHR – Spring Seminar

Socio-economic influences on the discharge of the River Rhine

Benefits and Impacts of Modern Pumped Storage Plants in the Austrian Catchment of the Alpine Rhine

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Bregenz, 26-March-2014

Topics

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- **Energy sector developments**
- **Modern technology of PHS**
- **Drivers and Benefits of PHS**
- **Obstacles for PHS**
- **Impacts of PHS**
- **Recommendations**

Existing scheme of Illwerke

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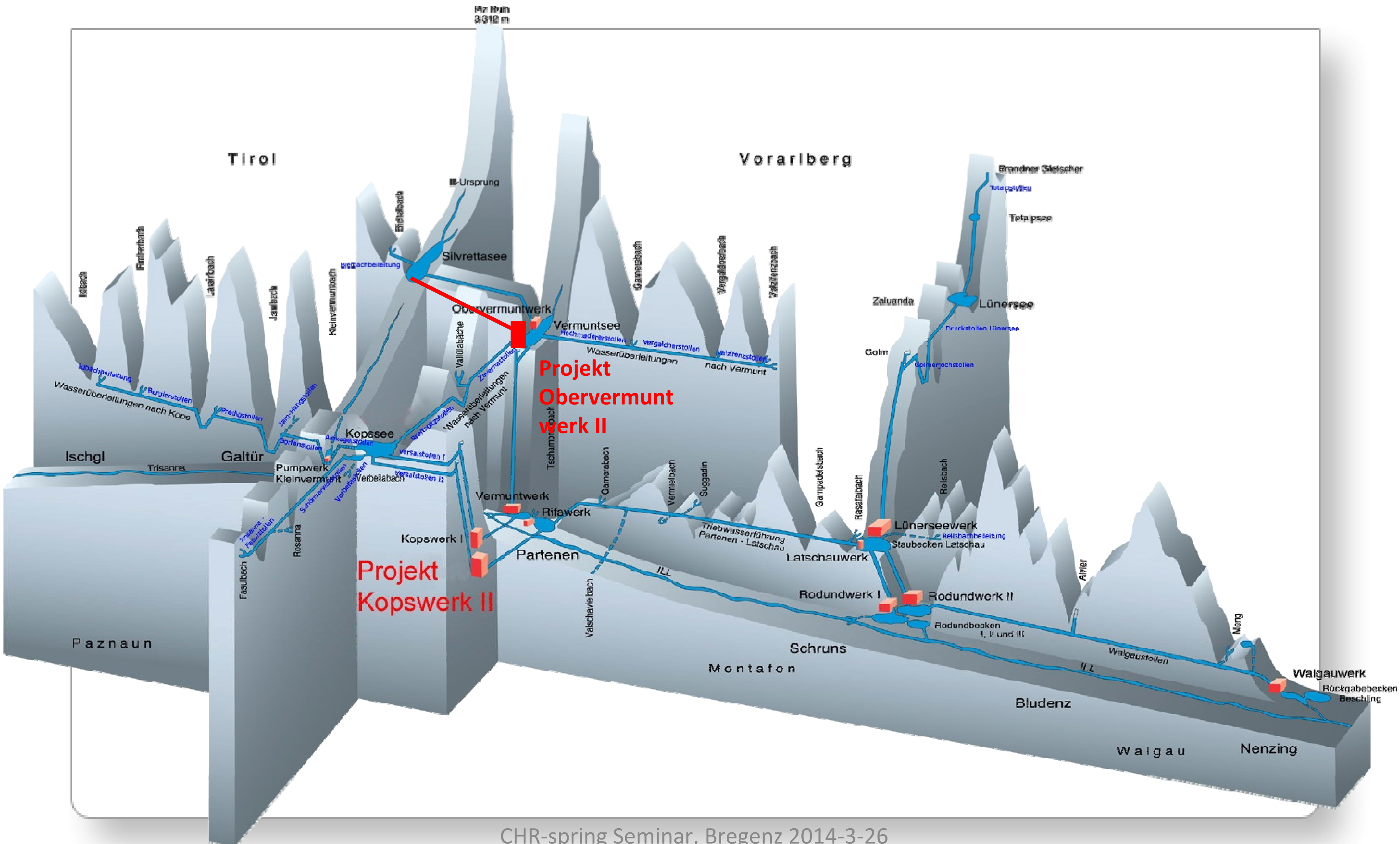
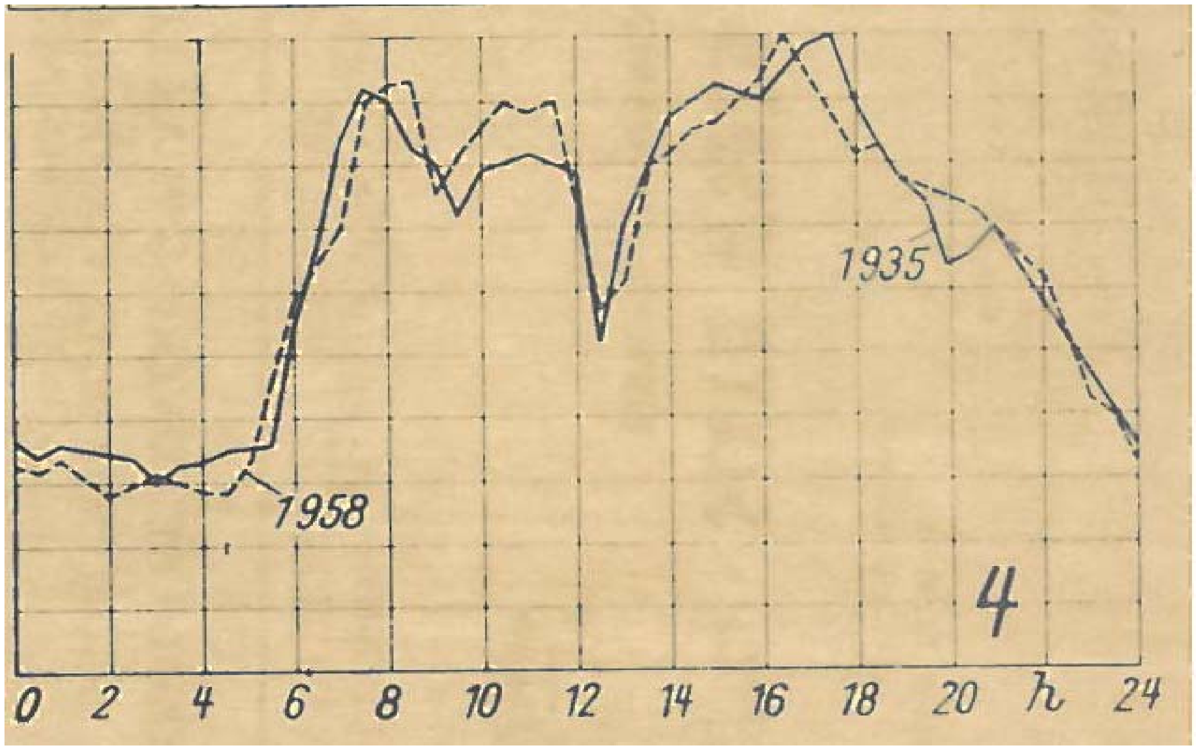


illwerke vkw

Load diagramm 1935 and 1958



Maximum of a day-load-diagramm
Energieversorgung Schwaben 1935 and 1958

Wind and PV impact to the market prices

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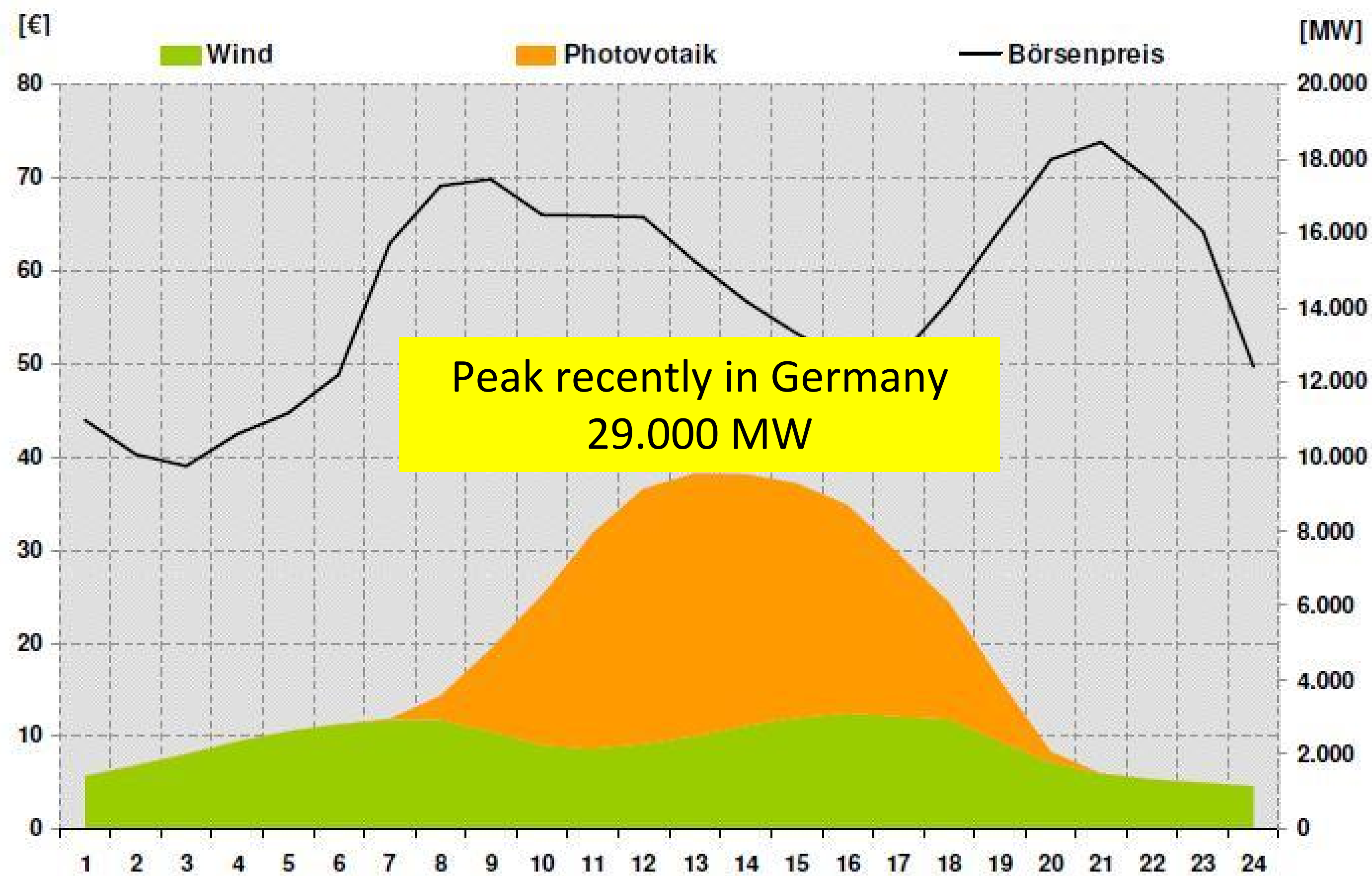

Week-load-diagramm 1960

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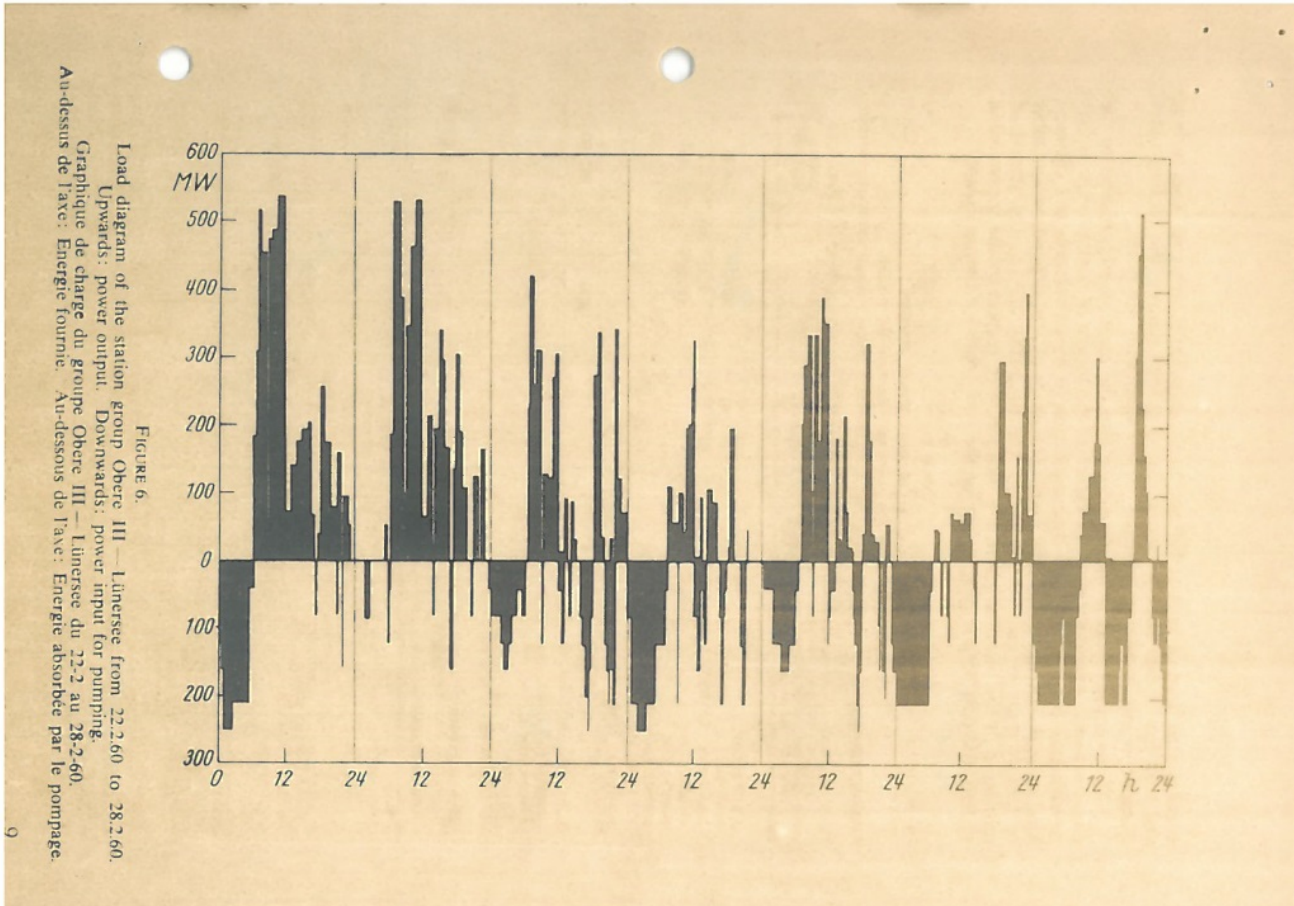
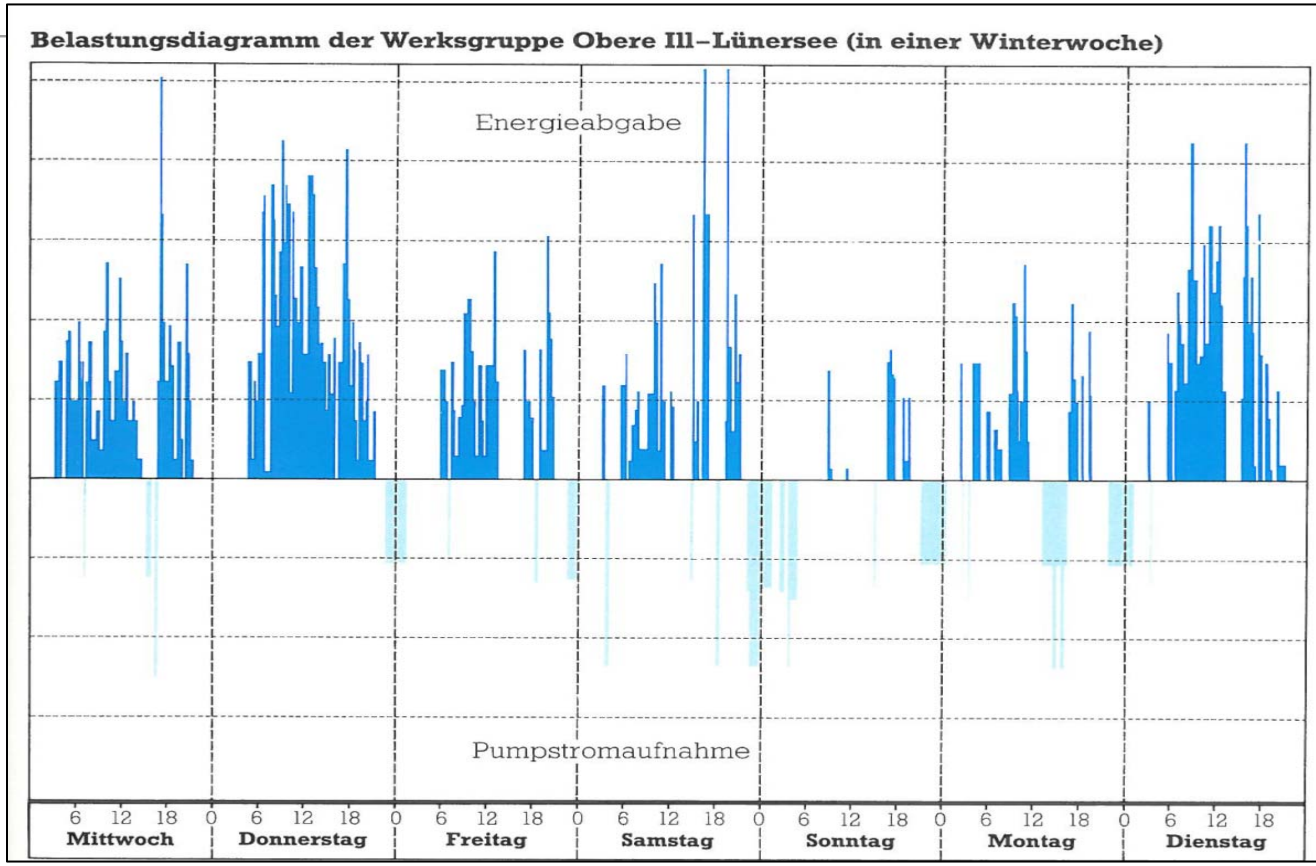


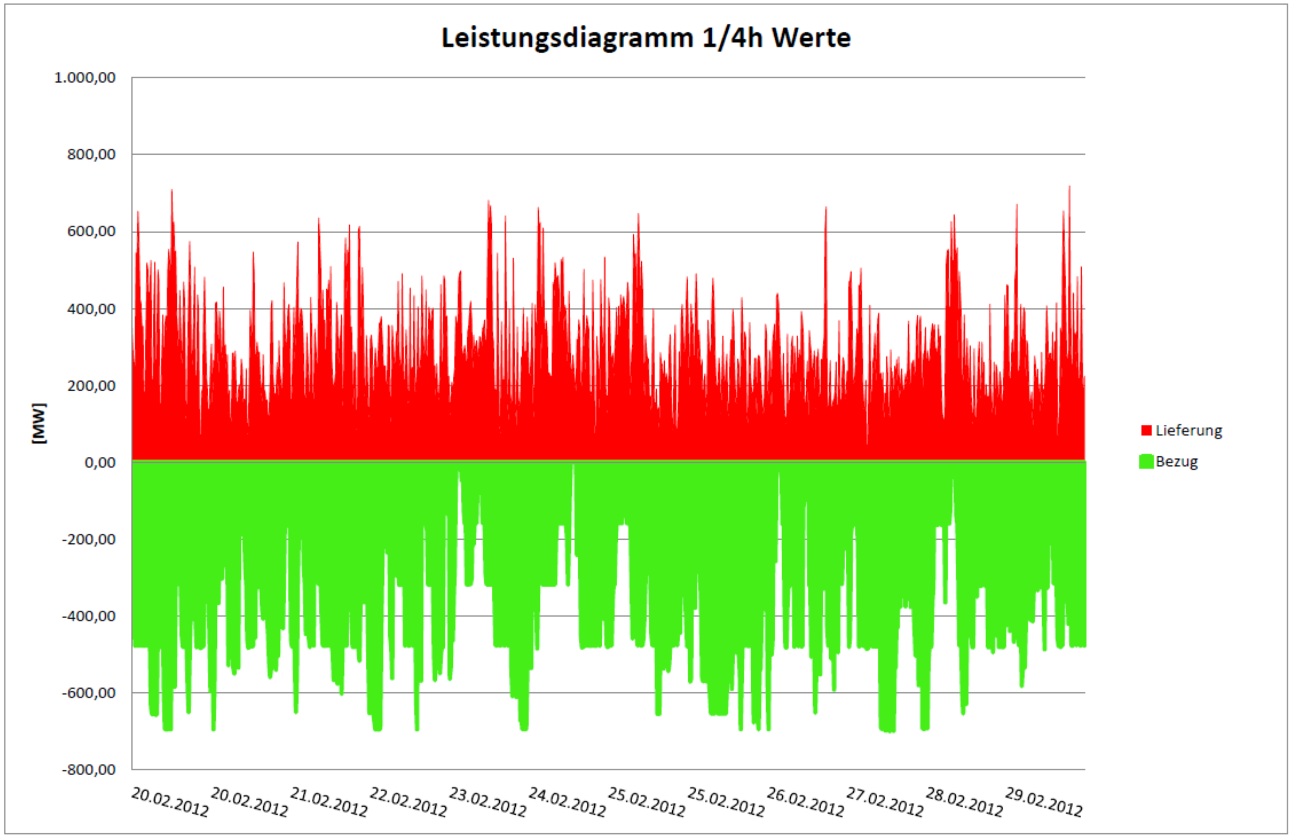
Werksgruppe Obere Ill – Lünersee vom 22.2.1960 bis 28.2.1960

Week-load-diagramm 1982



Werksgruppe Obere Ill – Lünersee
Winterwoche 1982

Week-load-diagramm 2012



Werksgruppe Obere Ill – Lünersee
20.02.2012 bis 29.02.2012

Residuallast aufgrund der RES

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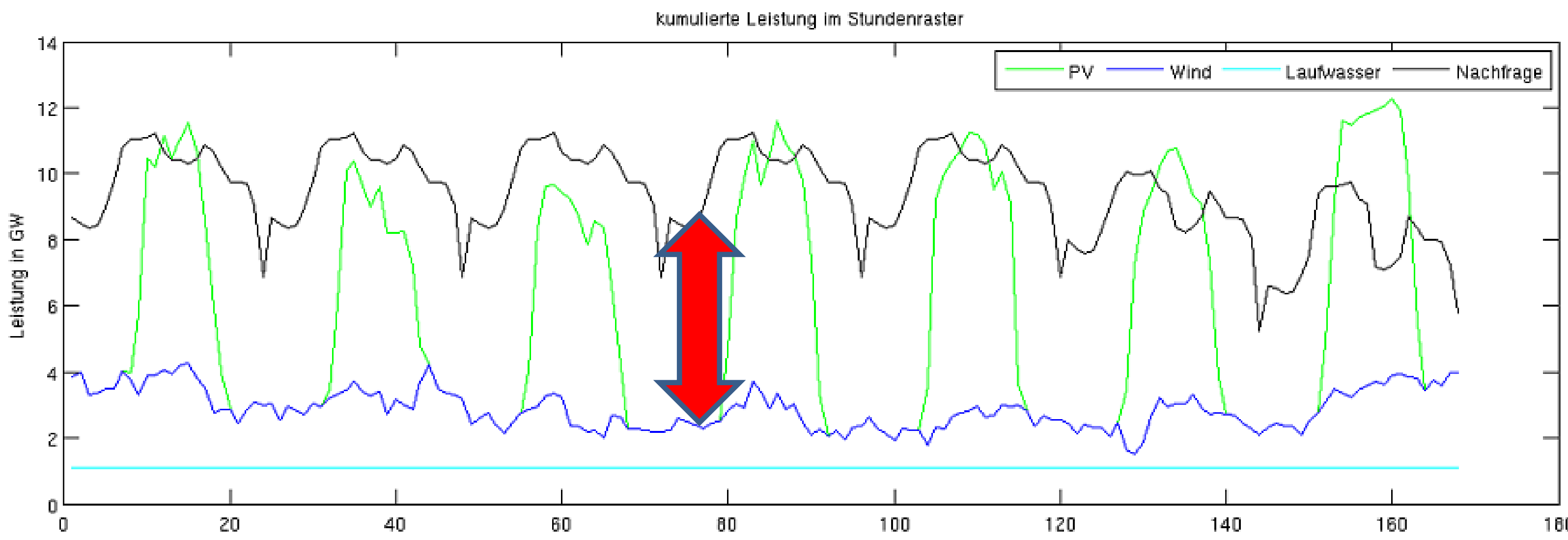
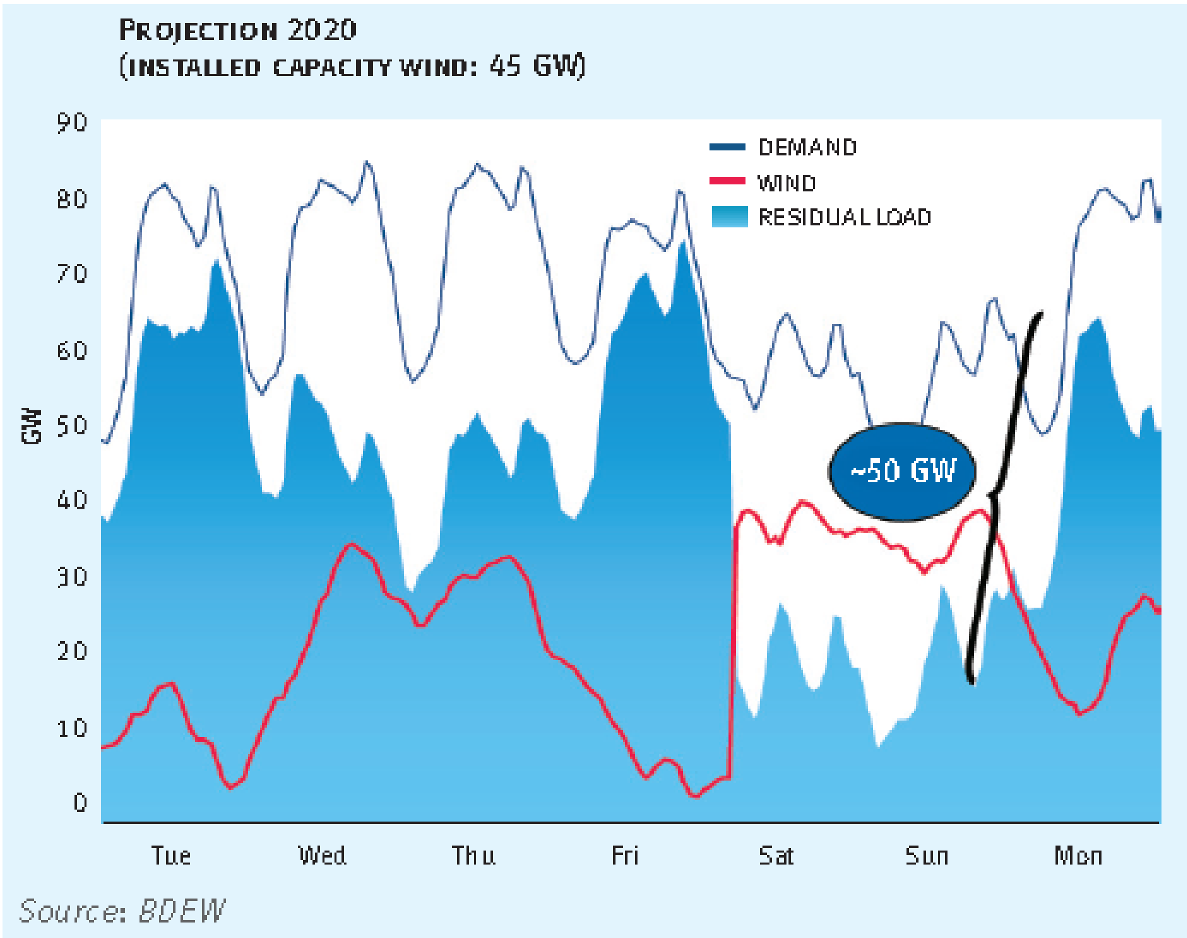


TABLE 2: VARIABLE RES INDICATORS IN GERMANY (YEAR-END 2011)

	WIND[5]	PHOTOVOLTAIC[7]	WIND + PV[7]
Total installed capacity	29,075 MW	24,990 MW	54,065 MW
Maximum generation[6]	22,795 MW (78%)	13,939 MW (56%)	26,479 MW (49%)
Minimum generation[8]	266 MW (0.9%)	0 MW (0%)	402 MW (0.7%)
Average generation[8,7]	5,145 MW (18%)	4,390 MW (18%)	7,374 MW (14%)
Maximum increase within 1 hour	4,348 MW	3,319 MW	4,348 MW
Maximum increase within 5 hours	7,744 MW	12,228 MW	13,907 MW
Maximum decrease within 1 hour	-4,723 MW	-3,299 MW	-4,723 MW
Maximum decrease within 5 hours	-8,507 MW	-11,863 MW	-14,966 MW

Source: BDEW

Prognose Residuallast ab 2020



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„The quotations at the power exchange inform more and more about current weather conditions and reflect less and less the true scarcity at the market.“

Andreas Mundt,
President German Federal Cartel Office
FAZ 20.07.2012

Example of the dispatch of a PHS

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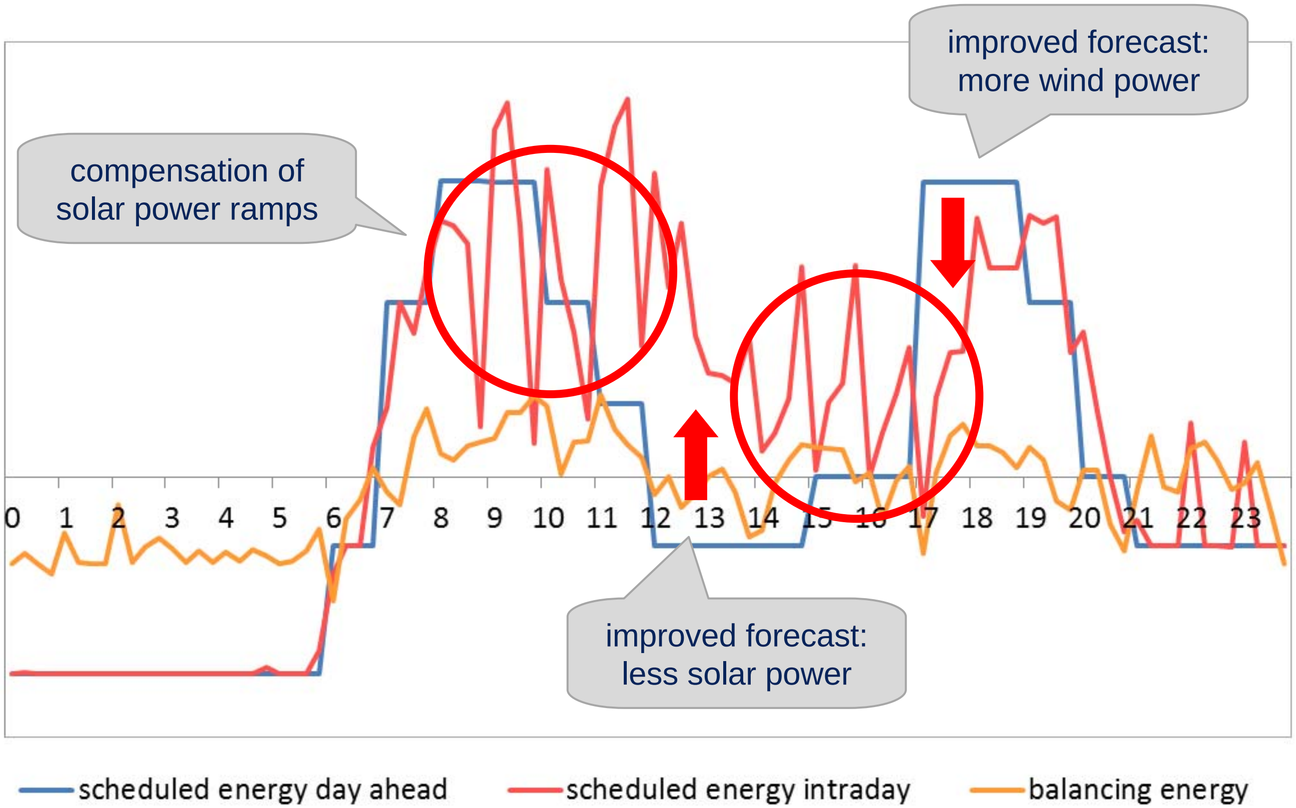
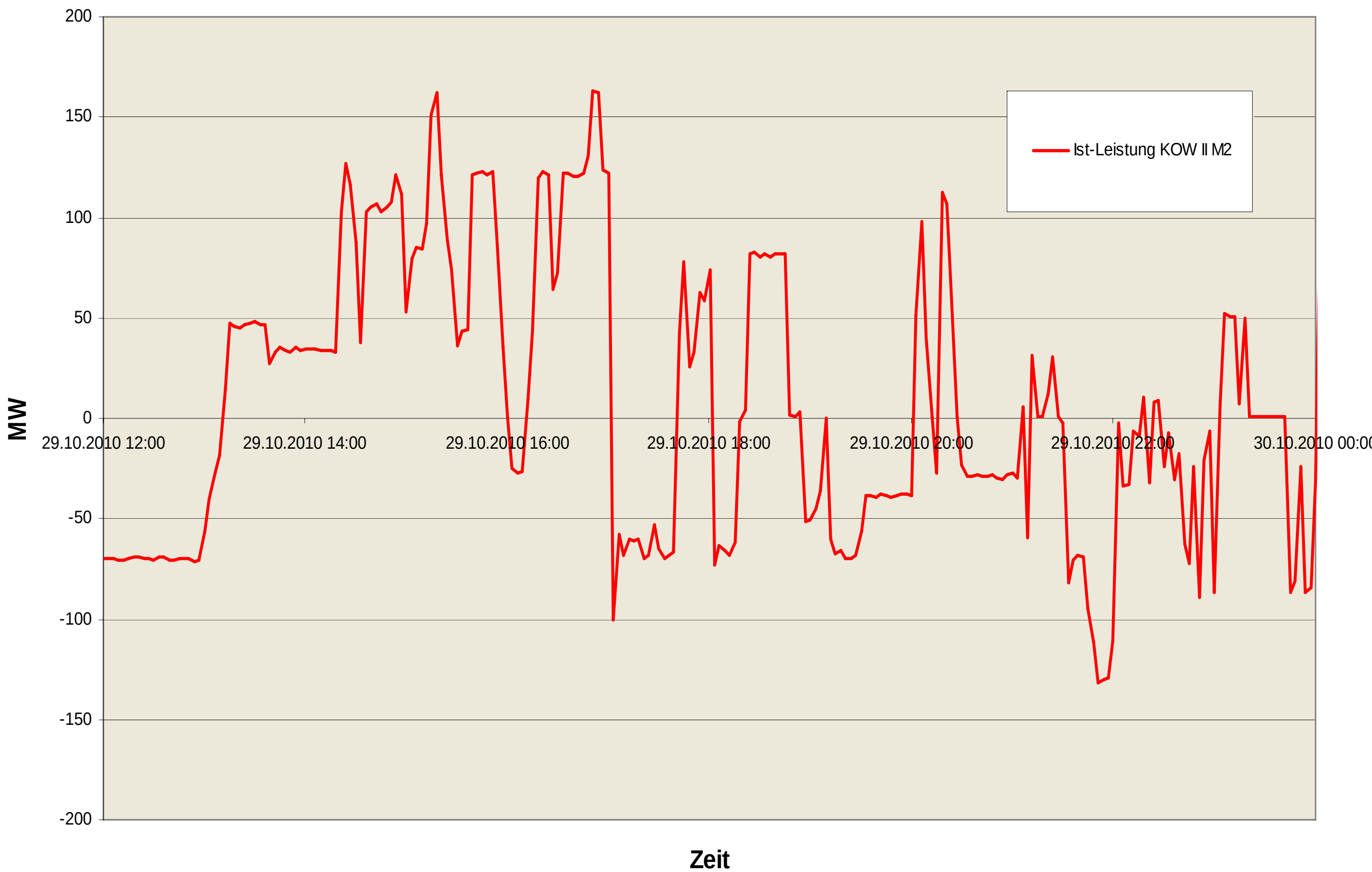


- Already today hydro- and pumped-hydro-stations make a substantial contribution to integrate wind and solar power

New Basic for Design:
Secondary control signal for one unit

typical day diagram, controllable pump mode

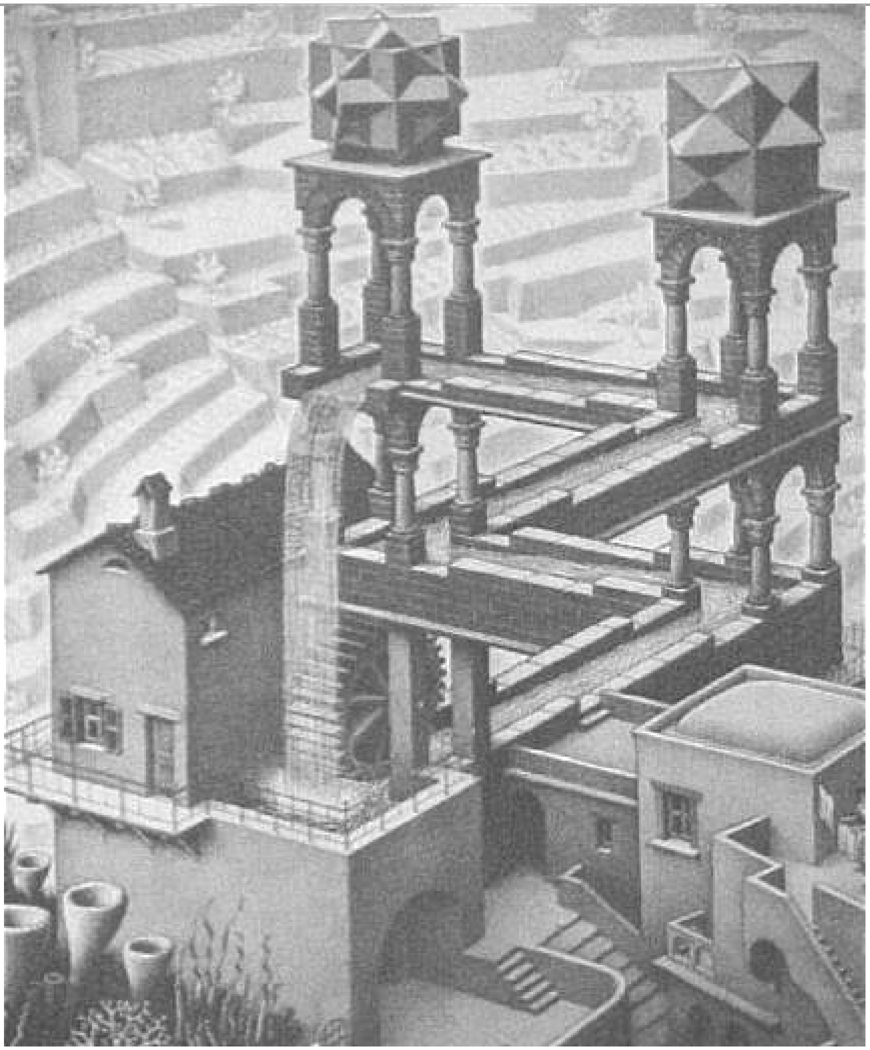


Hydraulic Short Circuit

Waterfall

M.C. Escher

1961



Old ideas rediscovered –
one of the turn keys of the future

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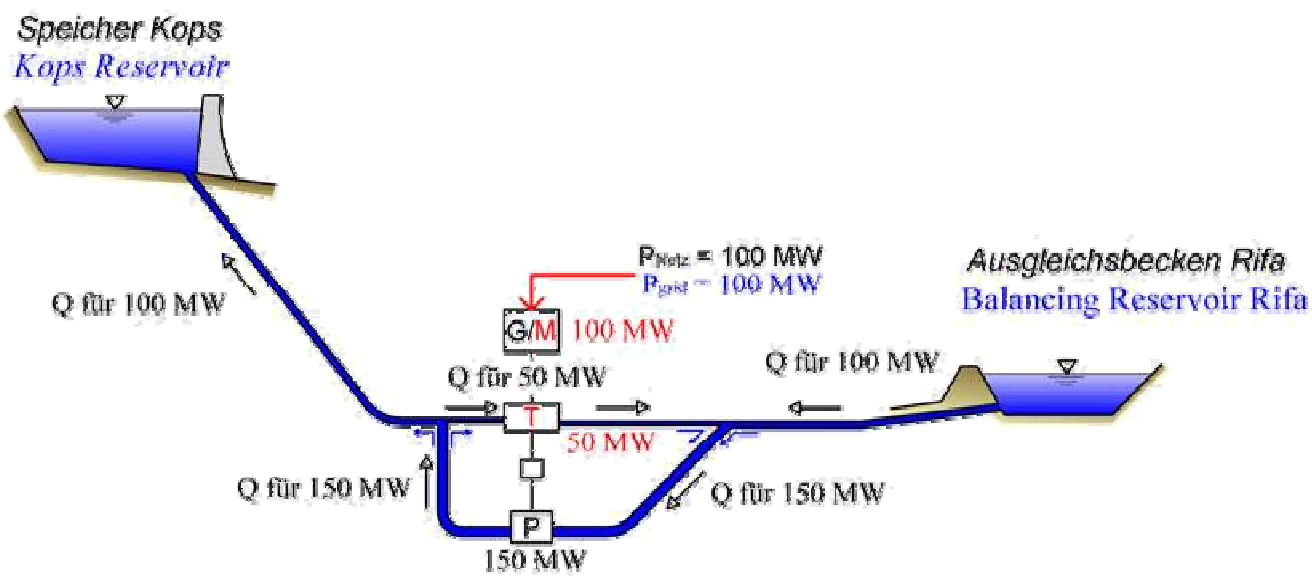
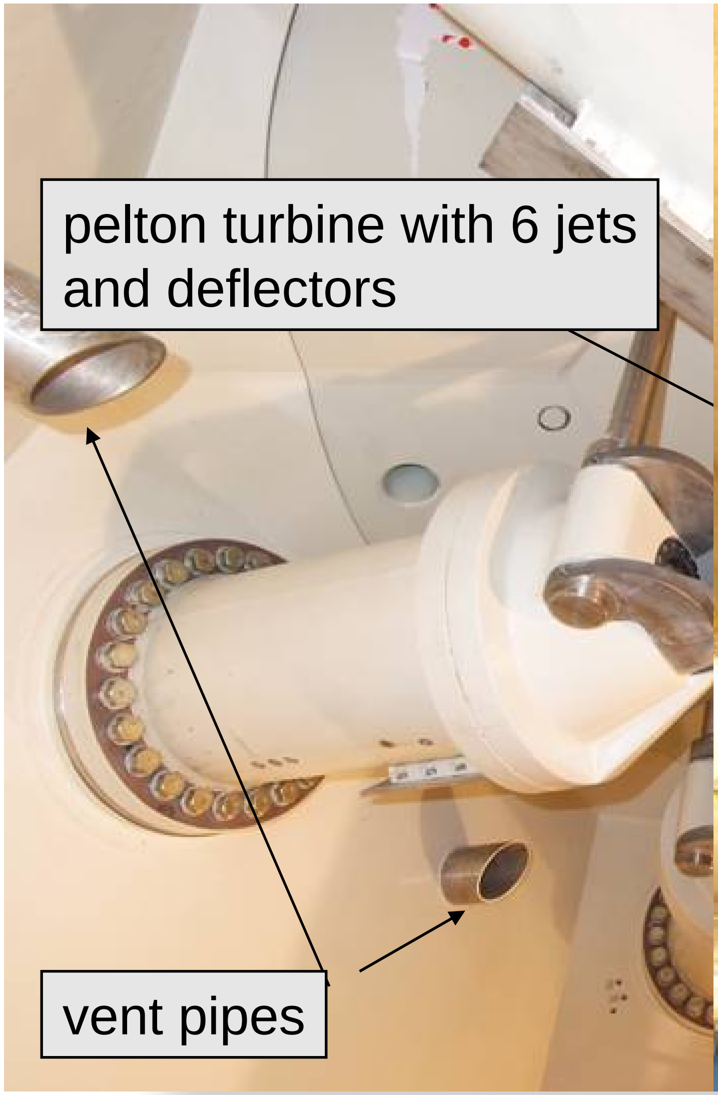
"Hydraulischer Kurzschluss"
z.B.: Überschussleistung im Netz 100 MW
Pumpleistung 150 MW

"Hydraulic shortcut"
e.g.: Power surplus in the grid 100 MW
Pump capacity 150 MW



G/M	Generator / Motor läuft mit 100 MW	Generator / Motor takes 100 MW from the grid
T	Turbine: (bei Kops II Pelton) erzeugt 50 MW	Turbine generates 50 MW
P	Pumpe "bekommt" 150 MW	Pump "gets" 150 MW
Q	Durchfluss	discharge

Kops II, machine cavern



Kops II

3 years of experiences
•8000 hours/annual per unit
•10 – 20 changes of operation mode P/T
•the flexible operation covers exactly the demand of the volatile energy market

What are the Drivers for PHS

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- Large existing reservoirs in the Alps with a huge capacity (GWh)
- Potential for increasing flexible capacity in pump and turbine mode
- Short middle and long storage possibilities
- Covering the primary, secondary and minute reserve with a flexible PHS
- Huge access to transmission lines Europe West

What are the Benefits of PHS

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- Well known and cost efficient technology with experiences of more than 8 decades
- high flexibility (in pump and turbine mode)
- High efficency (75 to 90 percent)
- Safe the system stability
- Integration of the RES
- Black start facilities
- Reactive power compensation

What are the Obstacles of PHS

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- **Double grid fees and excessive taxation for pumped storage, which is often treated both as generator and as final consumer**
- **Distortion of the level playing field because of discriminatory support for other storage technologies**
- **Claims of pumped storage ownership by transmission system operators (TSO) are not compatible with unbundlin requirements and would imply a reregulation of pumped storage**
- **Trade-offs between environmental legislation WFD and the low-carbon agenda**

What are the Impacts of PHS

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Laws and Directives:

- **New projects between existing reservoirs – parallel plants need a Environmental Impact Assessment (EIA) procedure. The main impacts are during construction phase.**
- **E.g. for existing PHS, hydro power plants, river engineering, control structures in water bodies etc.:**

  European Water Frame Directive (WFD), National Water Protection Plan (NGP) 2009 with the target to achieve „good ecological status or good ecological potential“

  - **until 2016: continuity in natural fish habitats**
  - **until 2021: e-flow, hydropeaking**
  - **until 2027: covered the targets**

What are the Impacts of PHS

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- For existing PHS or HPP
  - In priority fish habitat restoration of the continuity of waterbodies (fish passage up and down)
  - Eflow: residual water as measurement to achieve „good ecological status or good ecological potential“
  - Hydropeaking: actually there are some stides ongoing for development of fundamental principles

Case Study R&D Hydropeaking

WFD –> National Water Protection Plan

- **Less Know-How about effects of Hydropeaking**
- **R&D Studies about Hydropeaking at River Rhein (2012)**
- **Resistance against general statements**
- **cross-border exchange of experience** (Switzerland, Liechtenstein, Austria, Germany)
- **all parties (universities, ministries, experts and shareholders e.g. HPP) cooperation on round table**
- **Joint coordinated approach for R&D** (University for Natural Resources, Ministry of Environment Austria, Federal Department of Environment Swiss and 6 Energy Companies)

Consortium R&D Hydropeaking

Im Auftrag des Bundesministeriums für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft als Förderungsgeber, gemeinsam mit Partnern der E-Wirtschaft und dem Institut für Wasserbau und hydrometrische Prüfung als Kooperationspartner

Case Study R&D Hydropeaking

Current status of Research:

This study contributes not only to the research area by significantly increasing the knowledge on the effects of hydropeaking on fish and macro-zoobenthos but also represents a first important basis for the implementation and targets of the Water Framework Directive.

- **The impacts of hydropeaking could be defined with statistical methods for combination between hydromorphological and fish ecological status**
- **The cause of fish impairment is related more to stranding than increased drift effects**
- **The effects are strongest during the early life stage**
- **Interactions between peaking events and morphological habitat conditions play a significant role**

Additional studies and experiments as well as investigations of measures and combination of measures related to cost efficiency are necessary.

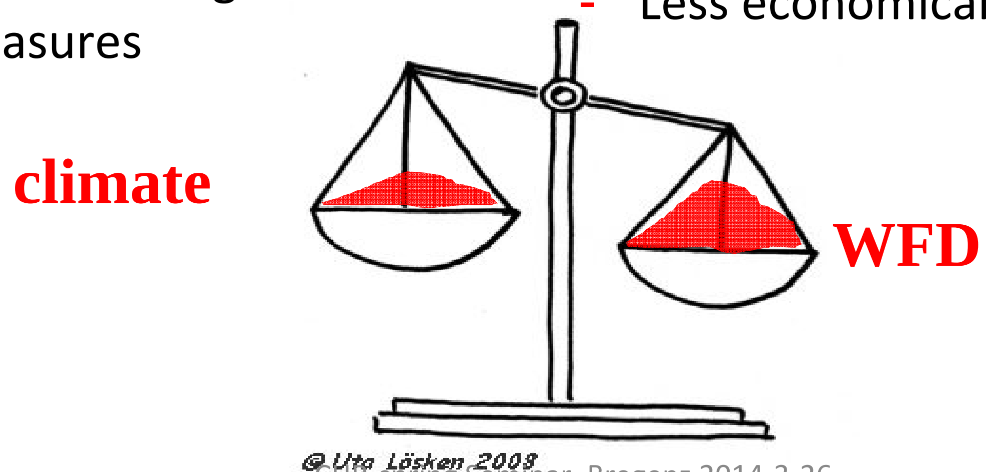
Case Study R&D Hydropeaking

Additional studies and experiments as well as investigations of measures and combination of measures related to cost efficiency are necessary.

Effective Measures Hydropeaking Trade-Offs

- \+ WFD „good status"
- \+ Joined Coordinated International R&D together with steakholders
- \+ accepted Basic Know How
- \+ Fine tuned package of measures at the end
- \+ Economical and ecological most efficient measures

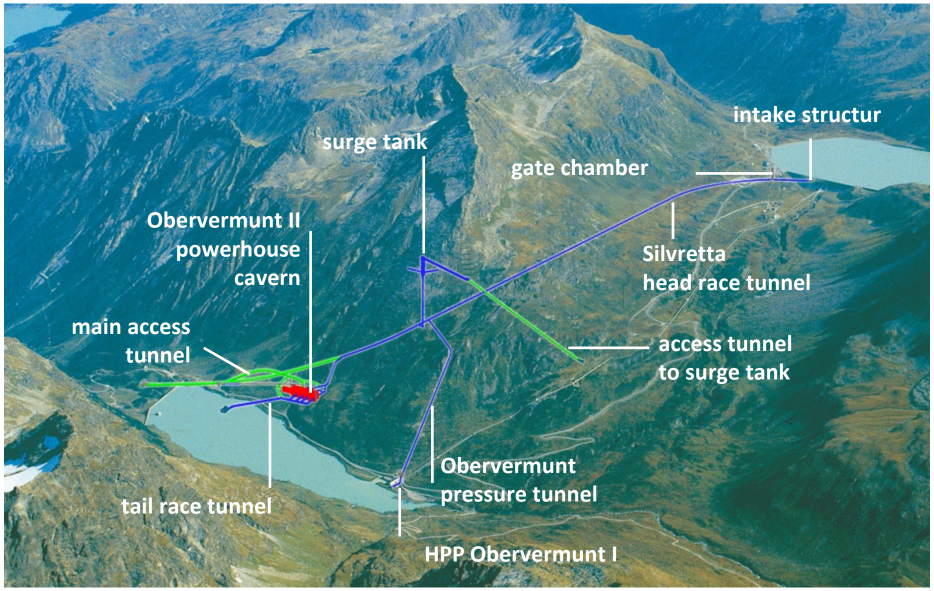
- \- Climate Protection Targets versus Targets WFD
- \- Reduction Capacity by PHS - Integration RES
- \- Reduction secureness of energy supply
- \- Little spur to invest for HPP
- \- Less economical efficiency



Recommendations

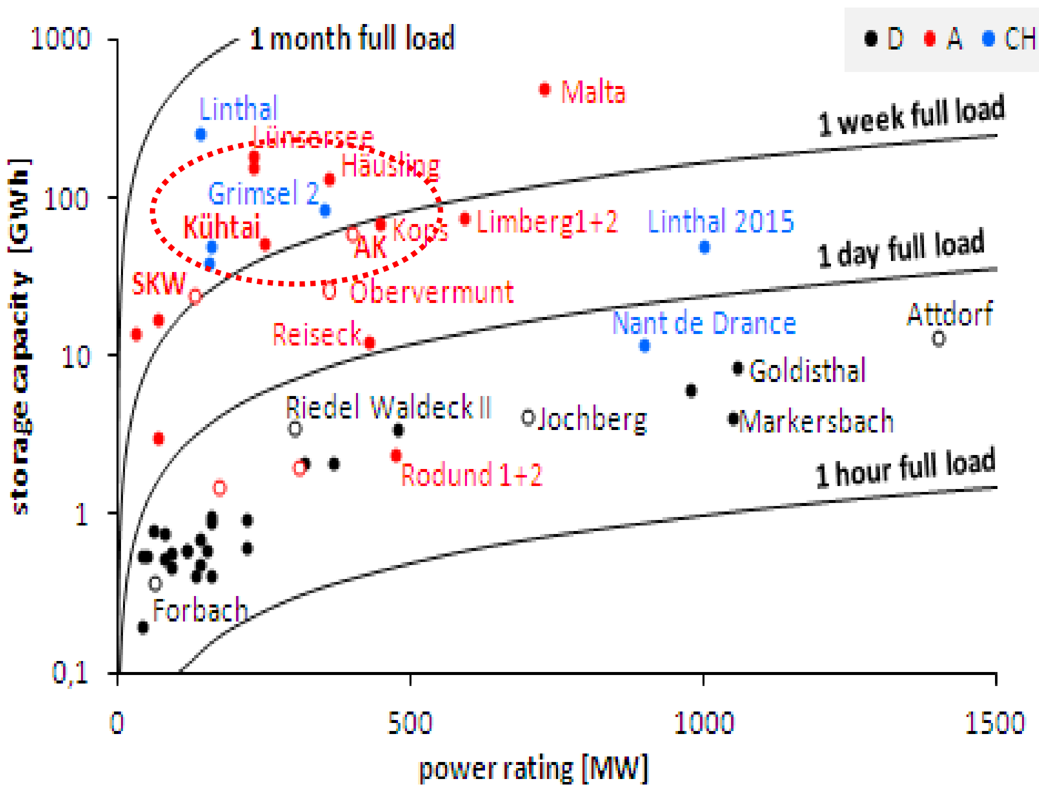
- **Measures to cover the requirements of WFD should be discussed with steakholders, experts and authorities from the same sector of ecology (e.g. Alps) with the target of a joint coordinated approach (R&D, Studies…….)**
- **Measures should be balanced between Water Protection and Climate Protection**
- **Best Practice and Common Sense**

Obervermuntwerk II



- **HPP Obervermunt II** is a underground pumped storage project located in western Austria.
- In course of construction, the **pressure pipe line** of the still existing power plant **Obervermunt I** is going to be **replaced** by a underground pressure tunnel.
- Obervermunt II is equipped with two horizontal **hydropower units,** each existing of Francisturbine, clutch, motor-generator, pump with torque converter
- <u>Technical data:</u>
  - **Power output** in turbine / pump mode: persistent adjustable from **+360 MW to -360 MW**
  - **Upper reservoir** Silvretta contains approx. **38 mio. m³** (70 hours max load turbine mode)
  - **Lower reservoir** Vermunt contains approx. **5,3 mio. m³** (11 hours max load pumpe mode)
  - gross head: approx. **300 m**
  - Discharge in **turbine mode**: approx. **150 m³/s** / discharge in **pump mode**: approx. **135m³/s**
  - Geometry of **powerhouse** cavern: length 115m, width 25m, height 35m
  - Energy transport: 220kV high-voltage cable from powerhouse to existing transmission line

Alpine HPS capacity to complete German daily HPS facilities.



[Ref.: EE, BES/TIWAG 2013]

The German HPS-system has short- term storage characteristics.

Reservoir – volumes and drop hights limit German hydro power storage facilities for short-term operation to maximum of 1 day.

All relevant strategy studies expect from 2025 on a significant increase of medium and seasonal storage when baseload capacity reduced stepwise and renewables' share will become dominant.

The challenges until 2025 can be met mainly by increased power installation (turbines and pumps) while post 2025 power and energy storage is needed urgently.

New Alpine HPS reservoirs will meet these challenges by progressive power and capacity development.