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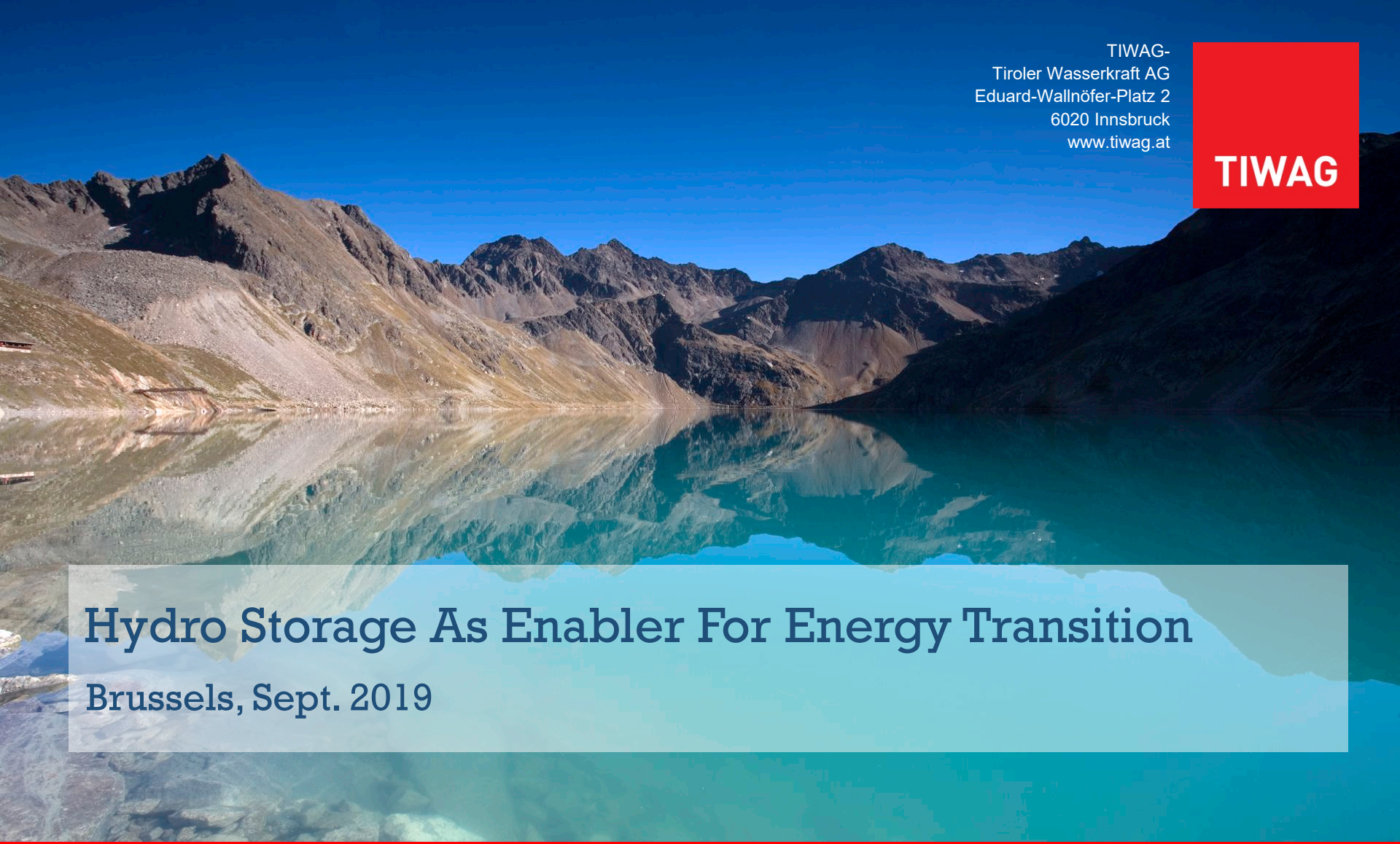

Hydro Storage As Enabler For Energy Transition

Brussels, Sept. 2019

Austria's RESE-Targets Cause Rapid Increase Of Flexibility Needs
In All Time Frames

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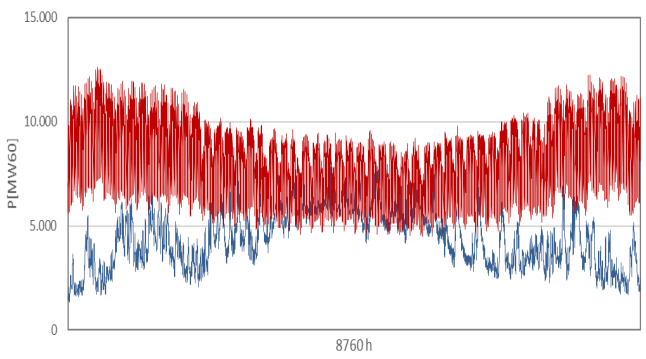
Climate and Energy Target Austria

Today: Due to hydropower Austria in EU28 RESE top position.

72 % RESE today → 100 % RESE 2030

- Hydro 39,8 TWh + ca. 8 TWh
- Wind 5,2 TWh + ca 13 TWh
- PV 1,1 TWh + appr. 13 TWh
- Biomass 4,6 TWh, no significant growth

2016

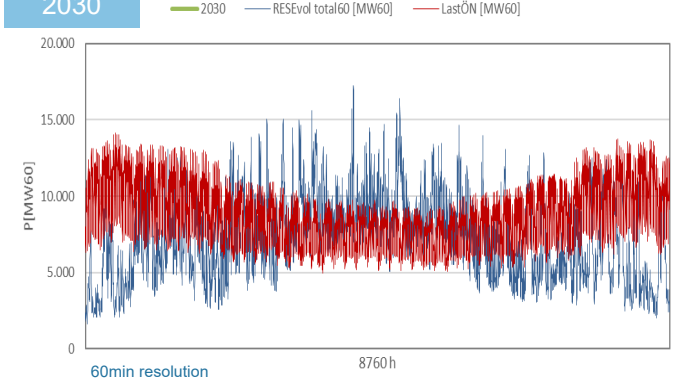


2016
Public Load
No significant prosumer effect.

RES-E Generation
Wind dominates fluctuations.
Seasonal characteristics effected by run off river and wind.
Peaks from May to October.

Residual Load
Positive residual load dominating.

2030



2030
Public Load
Increase of demand in winter.
Significant prosumer effects by PV self consumption.
Reduced public load in summer.

RES-E Generation
PV and wind dominate fluctuations.
Sesonal characteristics effected by run off river, wind, PV.

Residual Load
Significant positive and negative.
Significant summer surplus.

Residuallastanalyse für Österreich, Zufallsstichproben für 2016 und 2030

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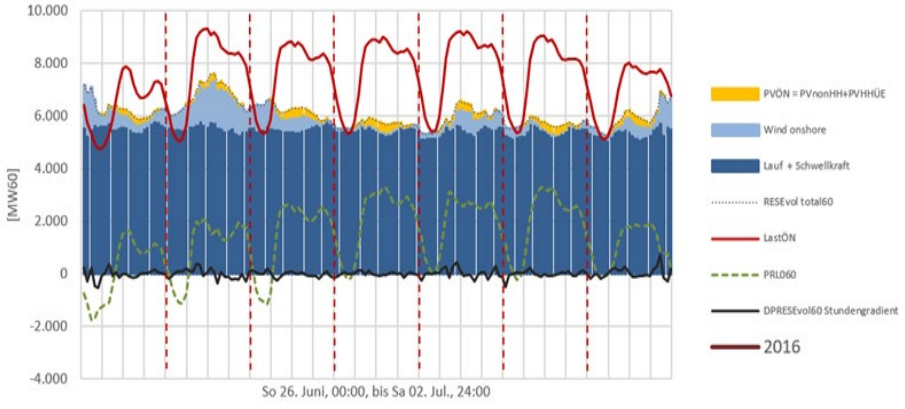
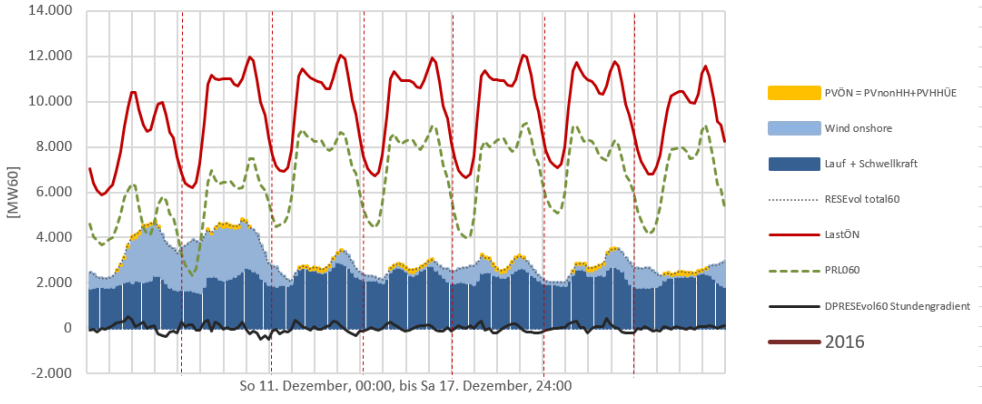
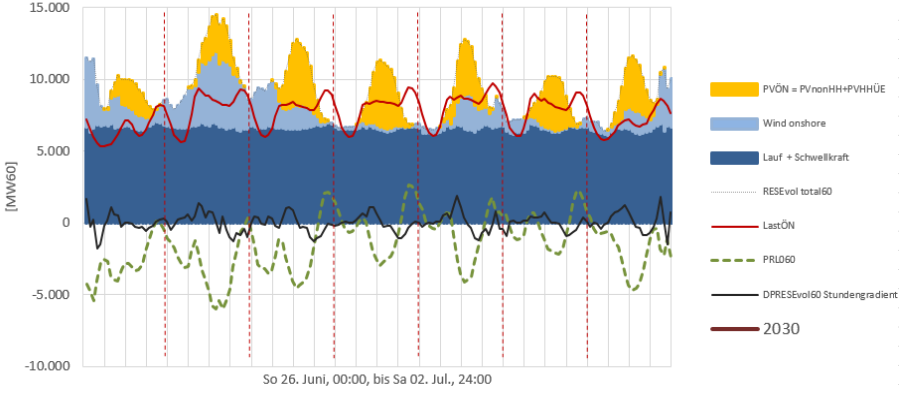
2016 Sommerwoche



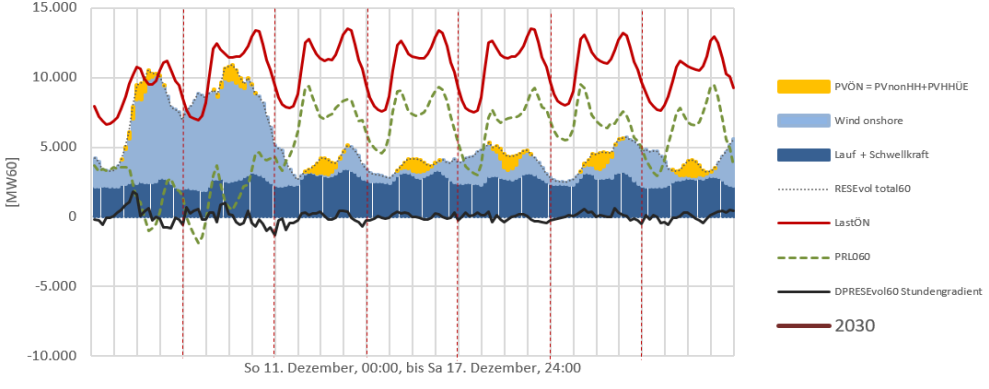
2016 Winterwoche



2030 Sommerwoche

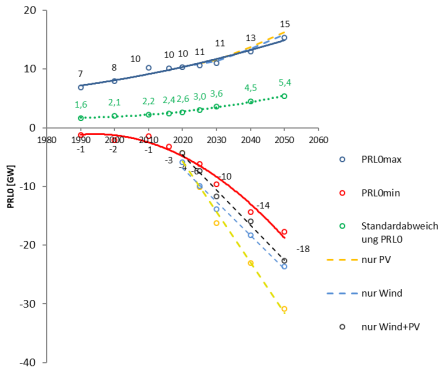


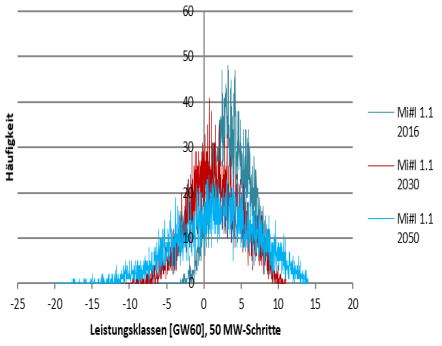
2030 Winterwoche



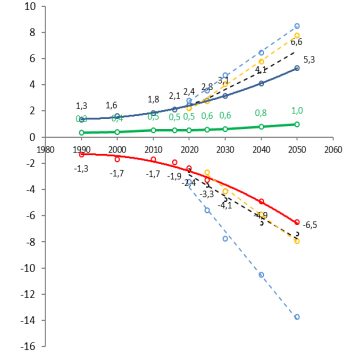
Rapid increase of short term flexibility needs expected.

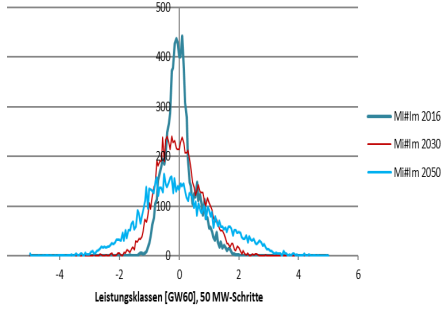
Peaks of residual load (GW)





Extrema of residual load ramps (GW/h)





Capacity characteristics

- Reduced frequency of low residual load, while higher values increase in both directions.
- Moderate growth of positive residual load peaks, while doubling of the negative peak value expected.

Ramping (Gradients) - Charakteristics

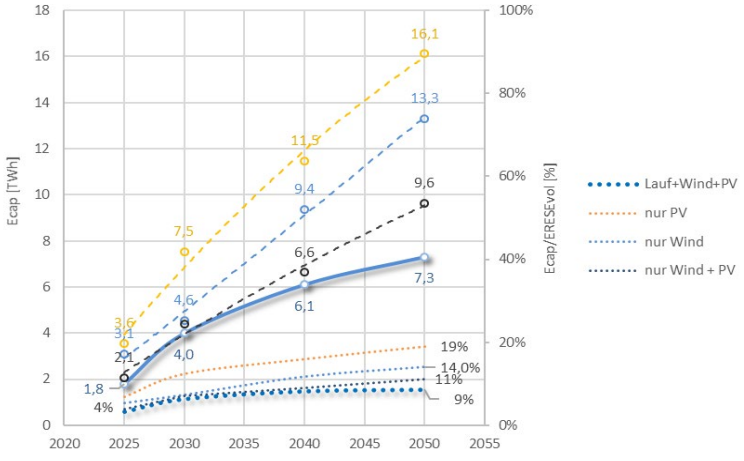
- Reduced frequency of low gradients, while numbers of higher gradients increase.
- Negative values dominating.
- Der maxiumum negative gradient expected to exceed the positive significantly.

Hydro Damping Effect

The combination of run off river together with wind and PV as such curtails residual load peaks and ramps significantly.

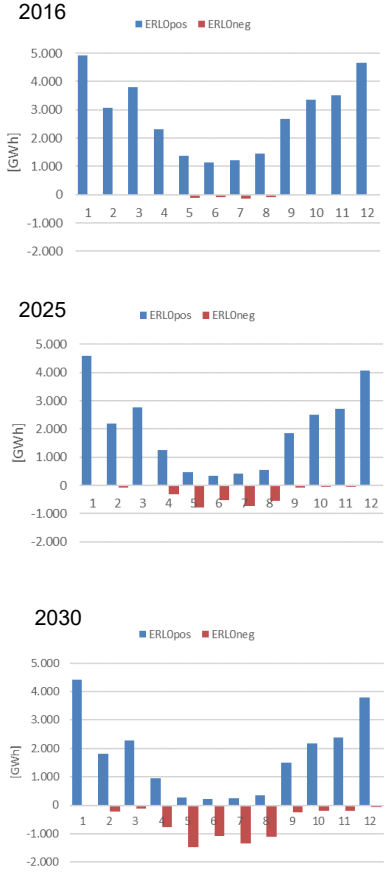
Rem.: Estimation by 2016 60min time series, scaled for 2030 and 2050.
Gradients < 60min may be expected even higher.
Hypothetical PVonly and windonly scenarios to analyse extreme conditions.
Detailed analysis for different weather years requested.

Capacity (TWh) Needs for Long Term Flexibility Increase Faster Than Residual Load Peaks.

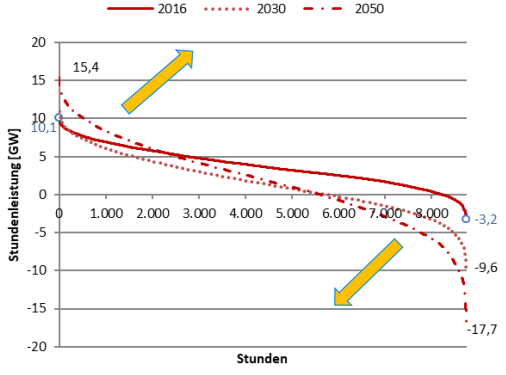


Fictitious storage capacity of Austria‘s electricity system plus existing capacity.

Positive and negative residual load RL (GWh), monthly cumulated.



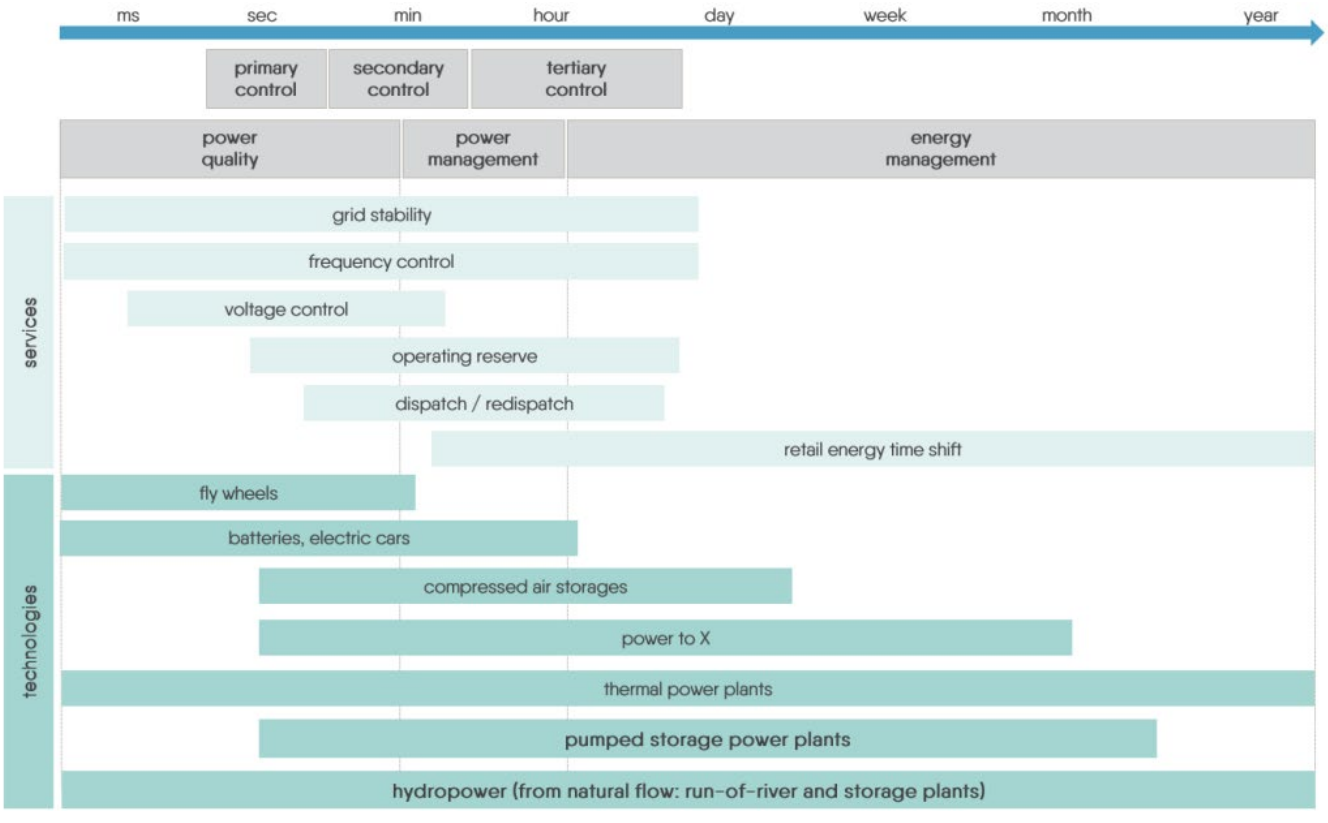
duration curve of residual load (GW).



Until 2030 energy of negative residual load (hourly power surplus) will increase by factor 7. Increasind need for storage capacity in all time frames.

Until 2030 the total of fictitious flexibility storage need is expected 4 TWh plus existing assets.

Hydropower As A Broad Band Flexibility Tool



Ref.: EURELECTRIC, VGB 2018

RES-Integration, System Stability and Security of Supply

Hydropower Storage and Pumped Hydro Storage Increase Their Key Role

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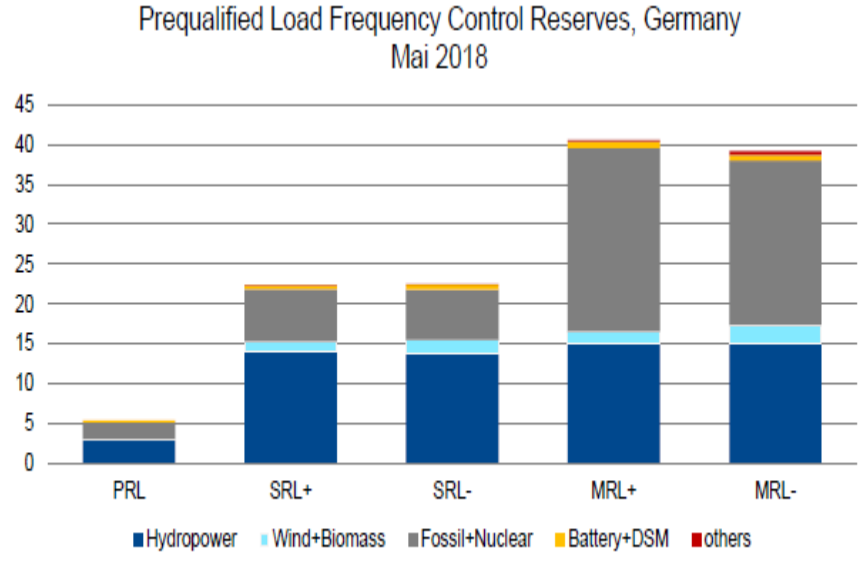

Source: https://www.regelleistung.net , 2018

Even in thermally dominated electricity systems (e. g. Germany) hydropower storage and pumped hydro storage play a key role to stabilize the system.

In future, even more relevant due to the reduction of fossil and nuclear genration capacity.

More Than Ever PHS Is The European System Stability Backbone – A Review

Ref.: ENTSO-E, TYNDP 2018

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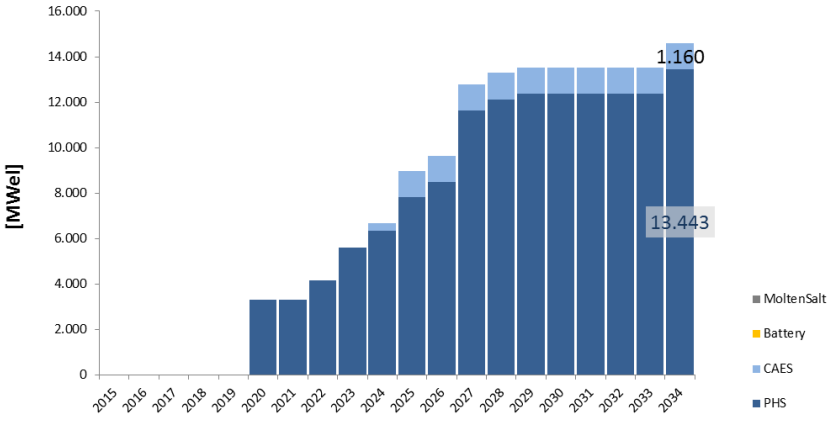
PCI Key Data: Infeed Capacity
e.g.: Turbine, ...
Ref.: TYNDP 2018 Storage Fact Sheet/PCI candidates Nov. 2018



PHS = Pumped Hydro Storage
CAES = Compressed Air Energy Storage
Battery = large central battery storgae
Molten Salt

Within the coming 15 years in total approx. 15 GW more storage capacity of system relevance will be installed for the benefit of the European electricity system.

Expected investment: more than 12 bn Eur.

Highly efficient pumped hydro storage plants share more than 13 GW (90 %) at comparably low costs.

Austrian projects in total share approx. 11 % of planned capacity and Kaunertal Extension Project shares 7 % of all PCI candidates.

The Psychology Of A System Change

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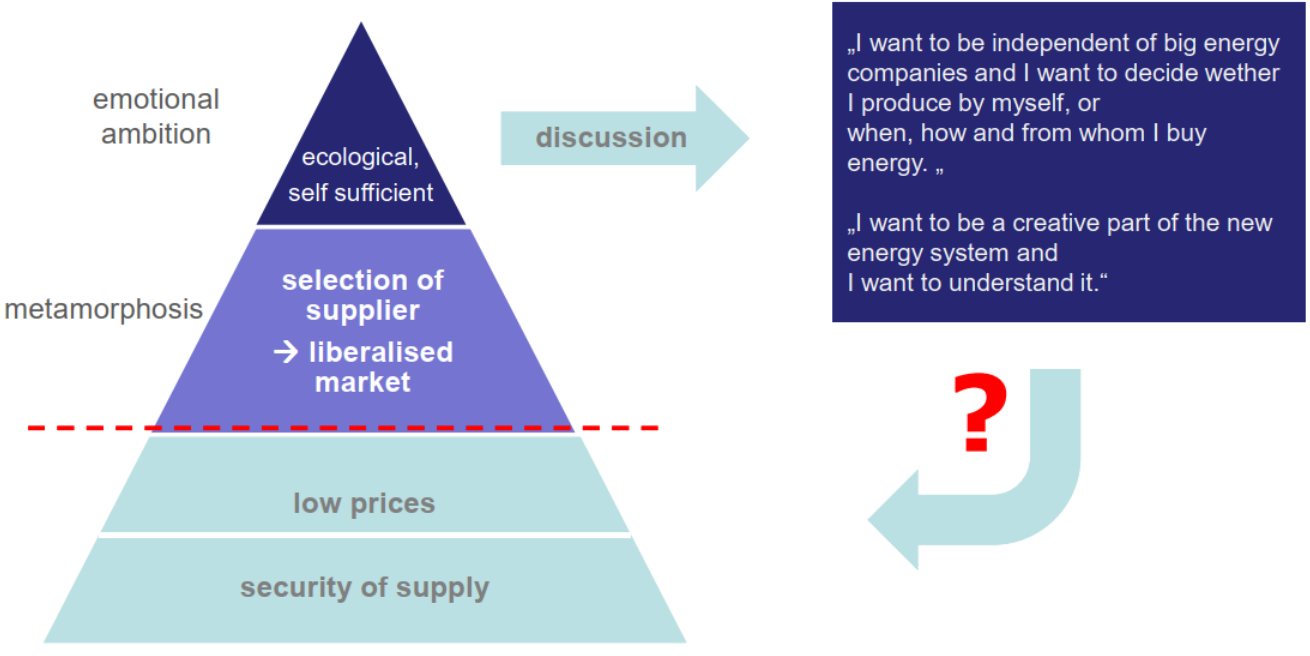

Vielen Dank

für Ihre Aufmerksamkeit.

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