Flexibility for the European Electricity Grid

Dr. Daniel Brand

SCCER SCHOOL ENERGY TRANSITION, 2016-10-19, ENGELBERG

BKW

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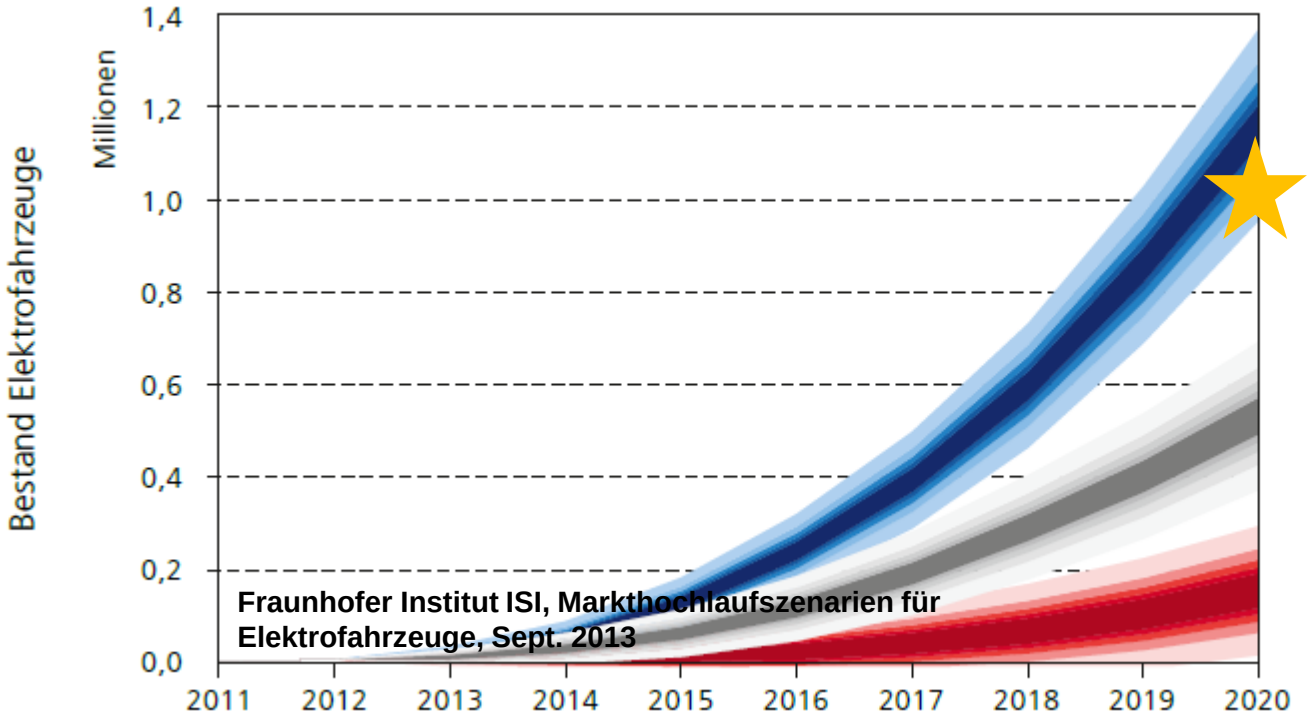
Planned e-mobility fleet in Germany



- Goal set by German government:
  1 Mio e-cars in 2020
- Range of battery driven cars will gradually increase

- **Make your guess!**
  - **How much accessible Capacity and Power will the 1 Mio cars represent?**
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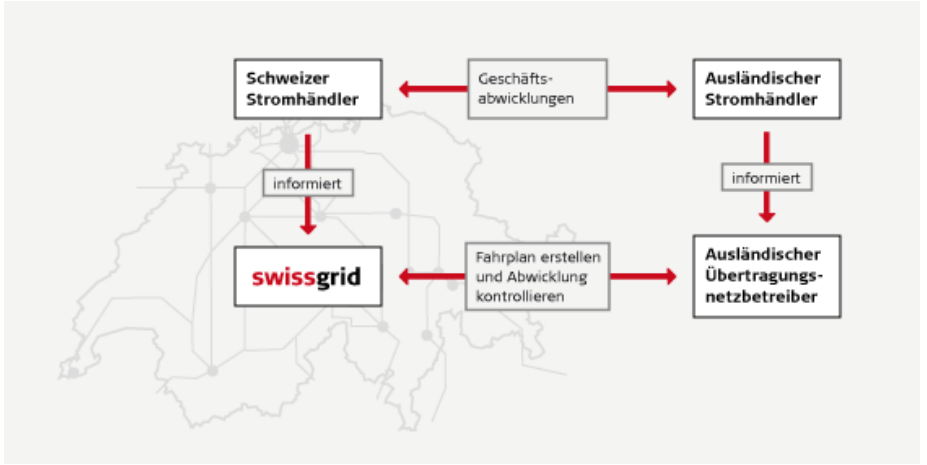
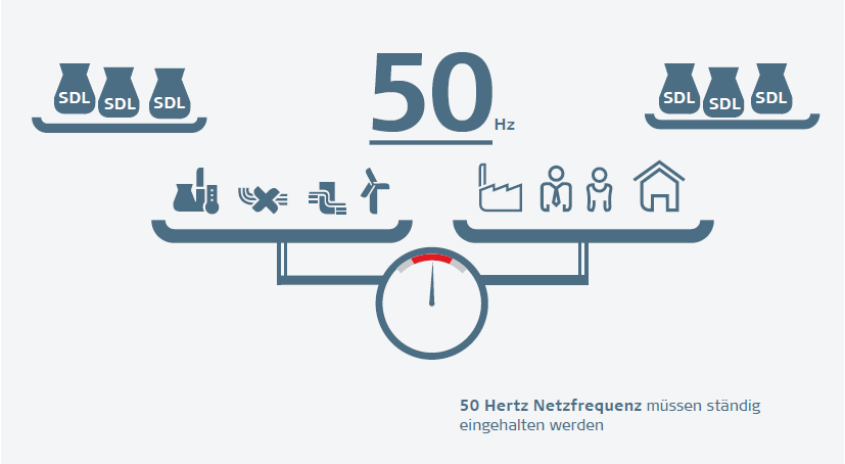
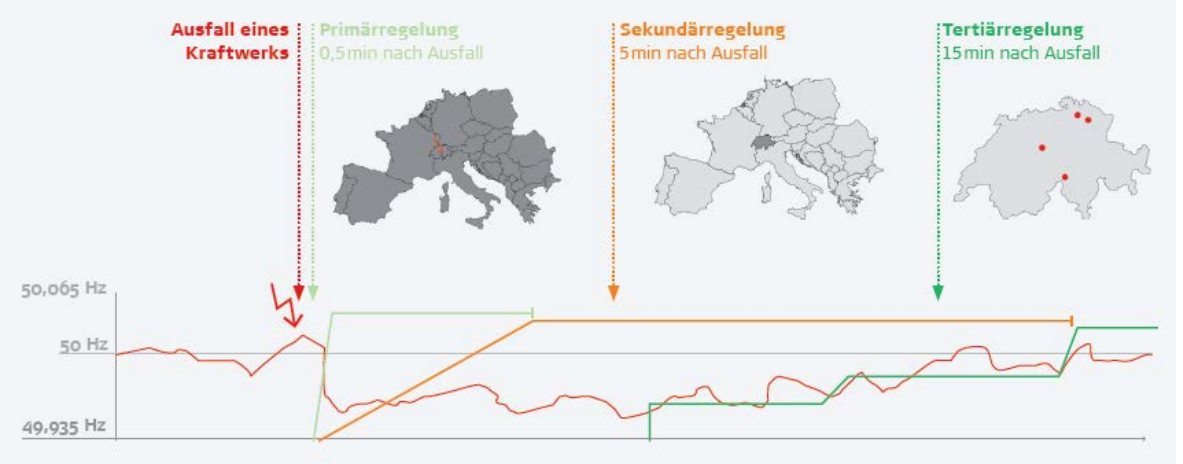
Switzerland's TSO: Swissgrid

- Ensures that traded energy can be transported.
- Is responsible for strategy, planning and operation of the transmission grid (220 and 380 kV)
- Is responsible for the availability of energy (ancilliary services, etc.)

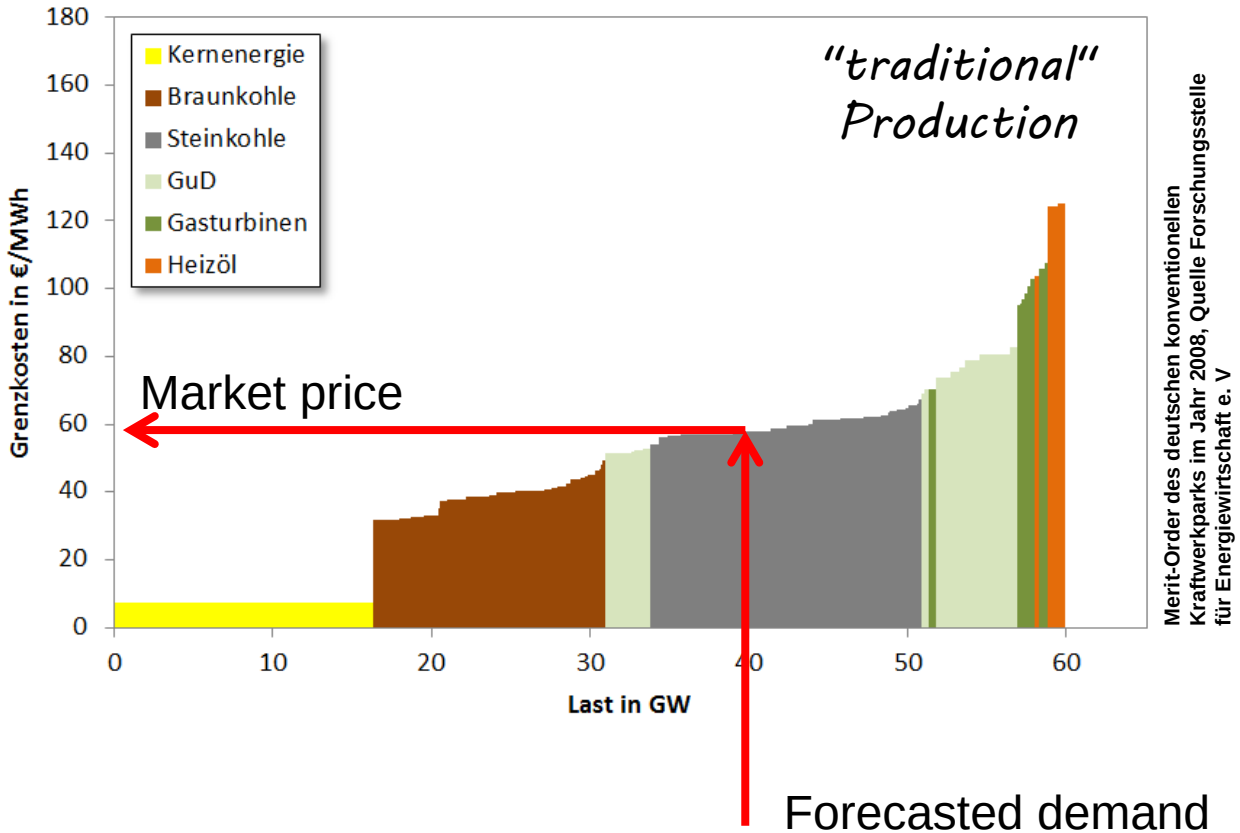




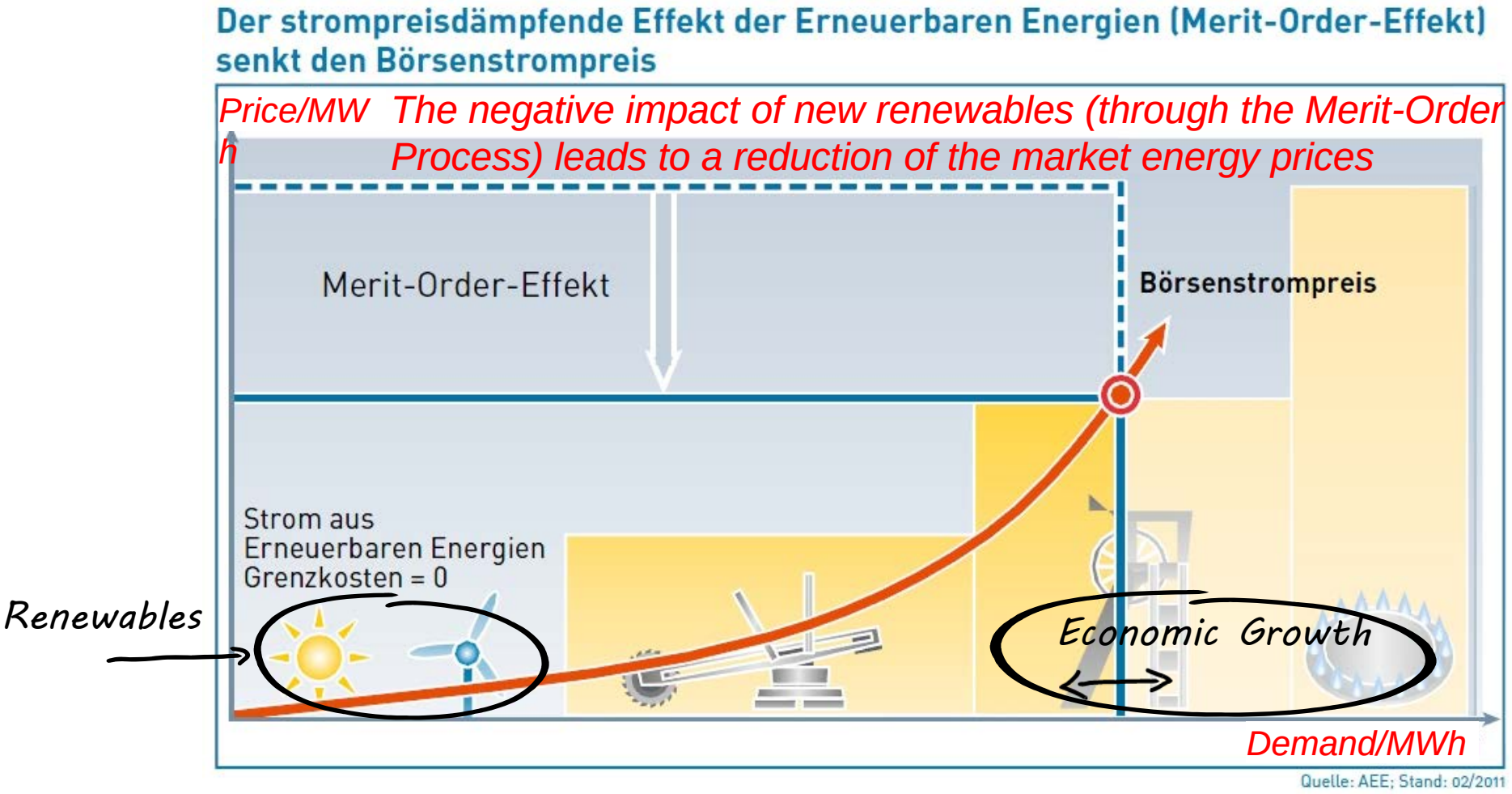


Energy Trade
The concept of "Merit-Order"

- Energy is traded every quarter of an hour
- The price is determined according to the concept of "merit-order":
  - Ordered from cheap to expensive, the last offer matching forecasted demand sets the price.
  - All offering parties with lower prices will be contracted at that price
- Point to discuss:
  - Why are marginal costs of wind and solar so low?
  - Advantages and disadvantages of price setting based on merit-order?



Energy Trade
Merit-Order Renewables



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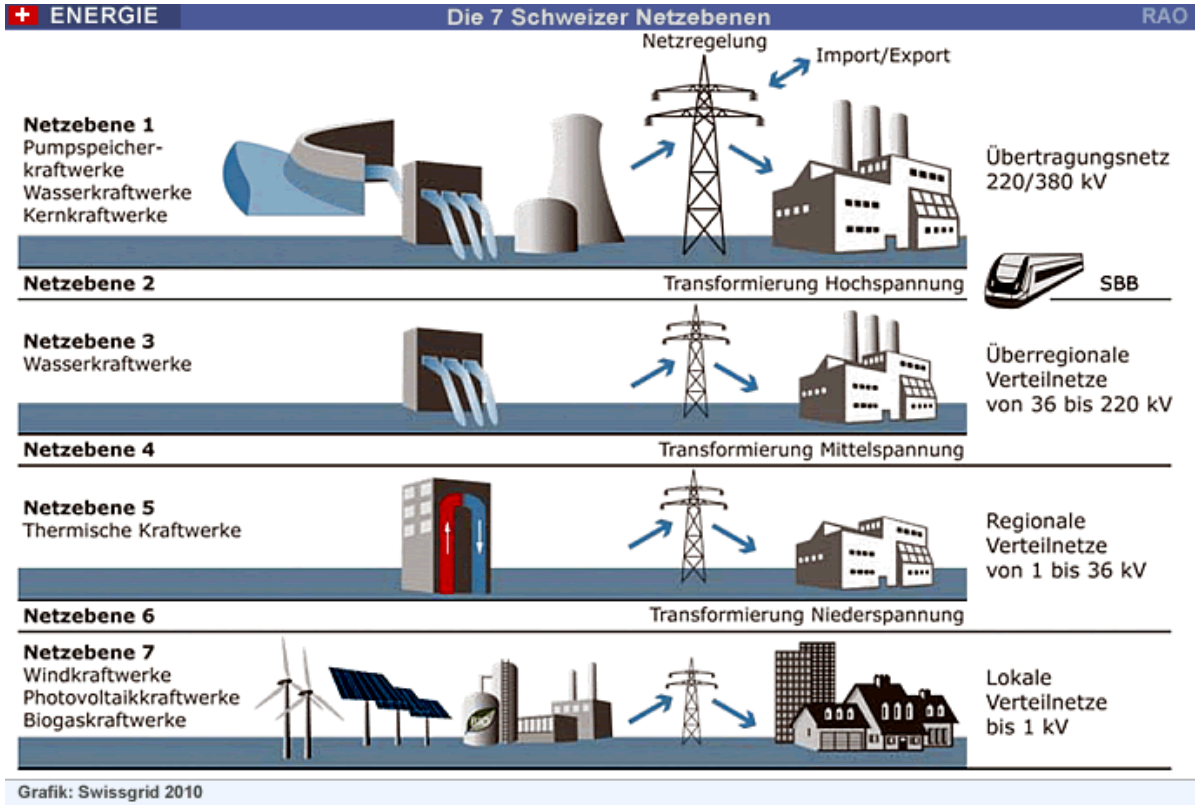
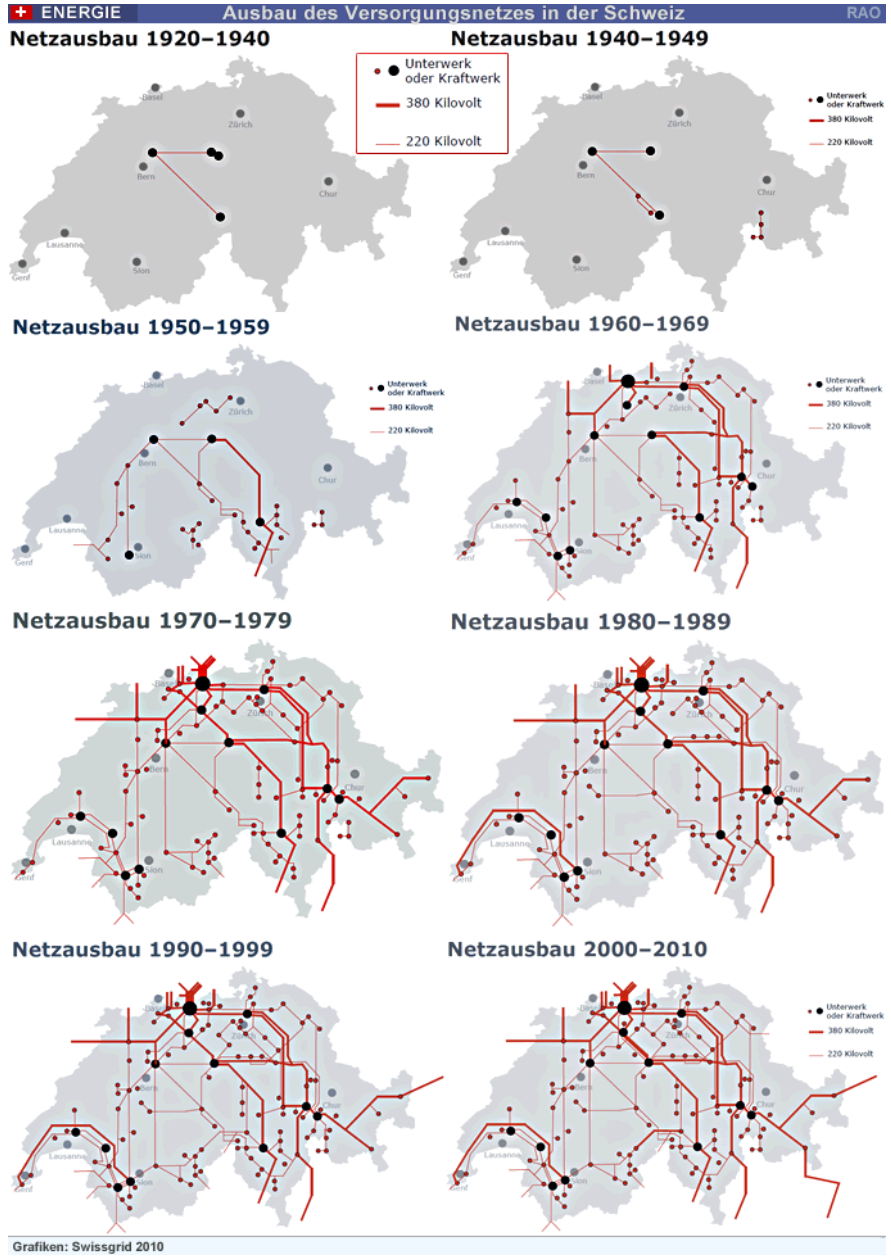
Transmission and Distribution Grid Levels



Grafik: Swissgrid 2010



Grafiken: Swissgrid 2010

Trends and Challenges

- Energy production is shifting **from large, centralized, dispatchable power plants to decentralized, stochastic production**: lower grid levels are subject to bi-directional electricity flows with higher peak loading.
- **The total rotating mass (stabilizing inertia) is decreasing**, "non-linear elements" such as inverters are becoming more frequent. This trend potentially lowers the robustness of the energy system and may impair power quality (sub- and super-harmonics)
- Due to decentralized production, **voltage control** at connection points to within ±10% becomes more demanding. Advanced design and control concepts are needed: regulated distribution transformers, reactive power control at inverters, active or static curtailing of stochastic power production.
- The electricity grid increasingly needs a corresponding **communication infrastructure**, down to grid levels 6 and 7.
- Ancillary services are increasingly offered by equipment connected to the distribution grid: **DSOs** will take over tasks from TSOs and **will need new management tools and methods.**
- **Forecasting** supply and demand **becomes more difficult** and more information is needed from DSOs.
- …

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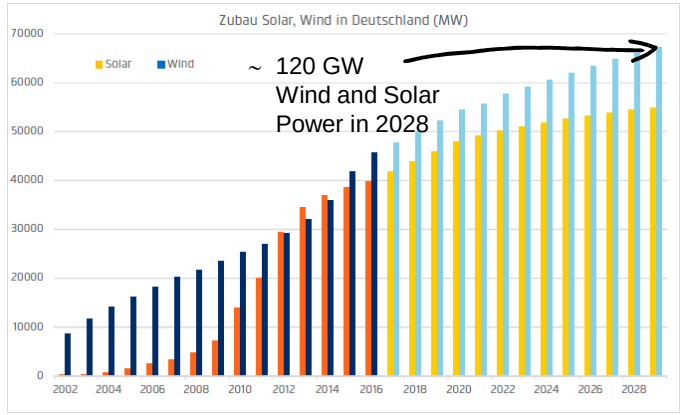
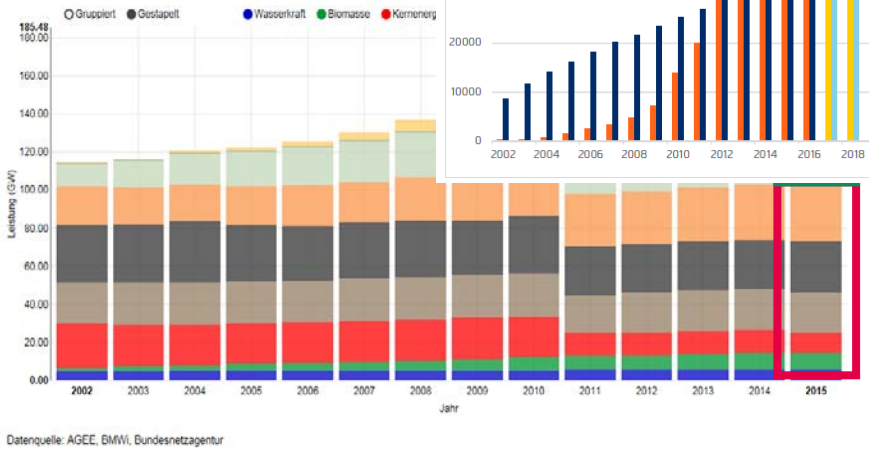
Renewable Energy Production

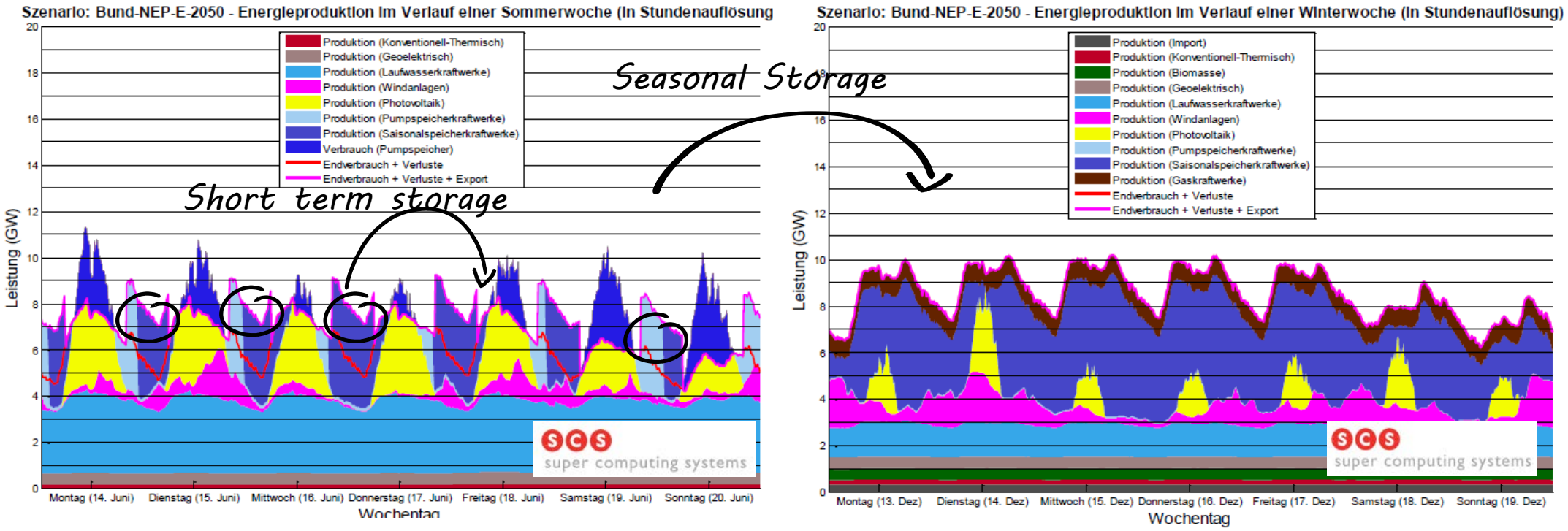
- The European Union (with Germany as driving partner) has ambitious goals for renewable power installations.
- Switzerland adheres to the Energy Strategy 2050 (more efficiency, more renewable energy, exit from nuclear power)
- Installation of renewable power is considerably subsidized throughout Europe
- Production costs for renewable power are dropping continuously, wind parks are among the most cost-effective production sites.





~ 100 GW
traditional Power

Supply and Demand during Summer and Winter



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Technology options for a more flexible energy system

- **Dispatchable Power**:
  Whenever possible, **base load production** (nuclear and combined cycle plants) should be **upgraded** for faster load response.

- **Demand Side Management:**
  Large consumers already govern their loads today so that they can benefit from periods with low energy market prices. Such processes undergo a continuous change. Aggregators enter the market **pooling flexibilities in order to profit from phases of lower energy market prices and to monetarize flexibility** on the ancillary market.
  Digitalization allows aggregators to pool small consumer components, such as hot water boilers or heat pumps, on household level. For example, BKW is working on such concepts.

- **Storage:**
  - **Electricity Storage** (Pumped hydro storage, compressed air, batteries (large, household-size, e-vehicles), flywheels, capacitors, …
  - **Cross-sector Storage:** e.g. Power2Gas, Power2Liquid
  - **Storage for Heat and Cold:** they may be large or small

- **Grid Re-enforcement:**
  - Grid re-enforcement increases energy transport capacity and **allows to balance regions with high demand with those having temporarily high (stochastic) supply**.

Various Requirements from different stake holders …

Grid operator:
- Uses storage as a means to optimize grid re-enforcement activities.
- Wants to operate storage in order to operate the grid with a loading which is as even as possible. Grid operators claim the "final call": they want to be able to intervene into storage operation when grid stability is at risk.
- Transmission Grid: likes to use storage for ancillary services: e.g. primary control or black-start capabilities.

Storage operator:
- Operators of large storage capacities like to sell services on the ancillary and energy markets.
- Operators of small storage, mainly private households, optimize their self-consumption and increase rentability of their PV system by collaborating with flexibility aggregators.

Trade:
- Prefers to have un-limited control over storage capacities to trade flexibility on energy and ancillary markets.

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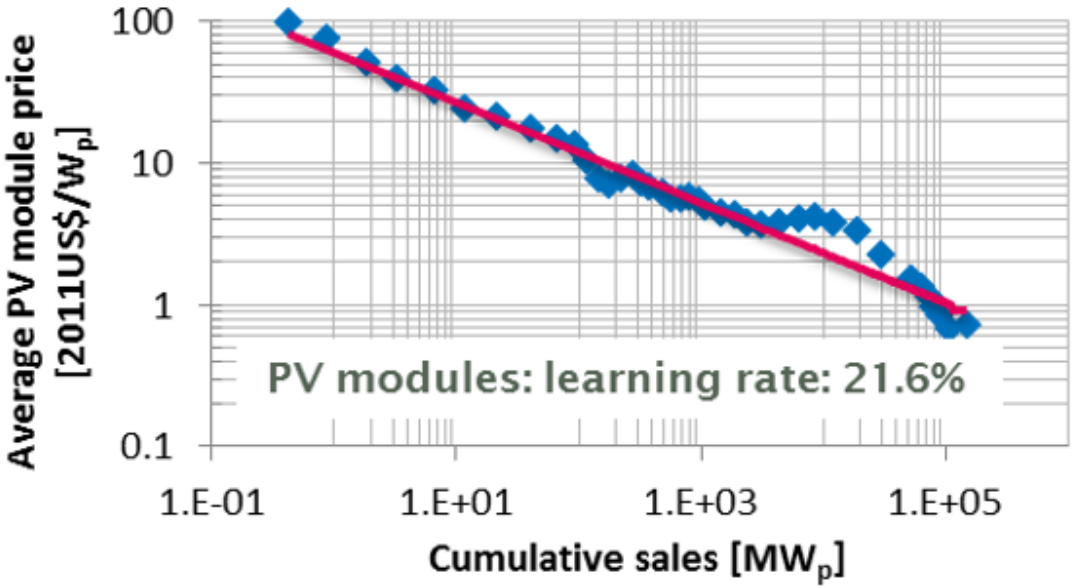
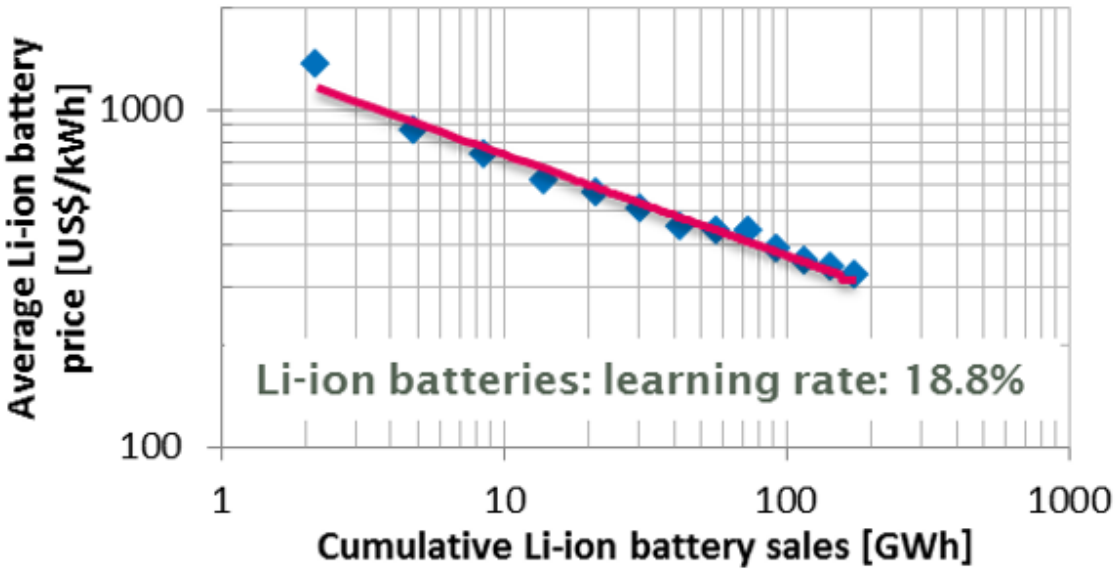
Storage capacities driven by alternative business fields (home storage, e-mobility, …)

- The **self-consumption** of energy produced with small privately owned roof-top PV plants is attractive as it avoids grid utilization tariffs. Grid parity (for residential use) is given in many European countries, already today.
- Storage utilizing small batteries increases the self-consumption rate. As storage prices fall, grid parity for stored energy will soon be reached in the European markets.
- Market penetration of **e-mobility** is still low as of today. However, growth rates are high. Large urban centers are working on strategies to phase out combustion engines on their streets. When connected to the grid, e-mobility offers storage capacity and even better, dispatchable power, once control schemes can be established.
- Home batteries and e-mobility will bring storage capacity and power to the grid, even without the actions of TSOs and DSOs. Utilization of such capacities may be available with **demand side management** systems at low marginal costs.
- Such **aggregated storage will compete with other storage capacities**, e.g. with PHS targeting at daily cycles. However, weekly or even seasonal cycles are out of scope for battery-based storage and will probably remain the domain of PHS or maybe Power2X technology.

Prices for PV-modules and storage



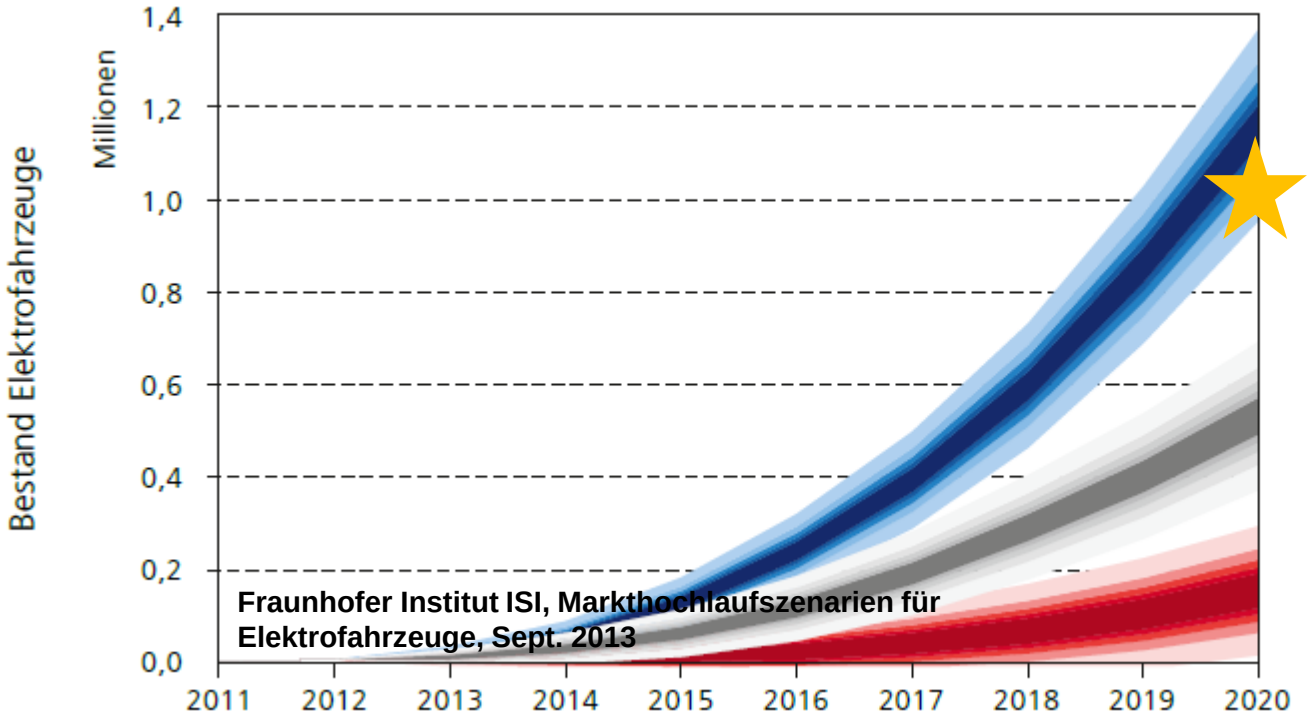
Own analysis based on data from ITRPV Working Group. *International Technology Roadmap for Photovoltaic (ITRPV): 2013 Results*. Berlin, Germany: SEMI Europe, March 24, 2014.



Own analysis based on data from Pillot, Christophe. "Li-Ion Battery Material Market Review and Forecasts 2012-2025." presented at the 3rd Israeli Power Sources Conference, May 29, 2013.

- *Engineering and installation costs not included (up to 50% of overall costs for residential-sized plants); they will not see the same decline*

Planned e-mobility fleet in Germany



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Summary

- **As far as Energy Transition is concerned, there is no going back: Politically desirable and economically reasonable.**
- Stochastic production is a challenge. The energy system will see a transition from **load following production** to **production following consumption**. This can be achieved by:
  - **Demand Side Management**
  - **Installation and utilization (new and existing) of storage**
- In parallel, the **existing production power is continuously being upgraded for more flexible operation** and
- **Re-enforcement of the transmission grid** allows for balancing regions with high demand together with those with high (stochastic) production.
- Further challenges are (local) voltage and current peaks in the distribution grid. **Control concepts and regulatory frameworks** are needed to utilize decentralized production and storage infrastructure **for grid stabilization purposes**.
- The energy system will see installations of storage driven by alternative business fields (residential batteries, e-mobility, power2gas, …). Such storage capacity may be accessed by aggregators through **demand-side management systems** at only marginal costs.
- **It is assumed that the future energy system will have sufficient short term storage capacity (daily cycles) but seasonal storage at economically feasible costs will be more difficult to achieve.**

Thank you for your attention!

Dr. Daniel Brand
daniel.brand@bkw.ch
www.bkw.ch

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