

# Challenges facing the power systems

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# Stages of power system growth

There are three distinctive periods in power system evolution:

- 1. Technical development:** from 1891, when Siemens constructed a three-phase power line for International Exhibition in Frankfurt. This stage was characterised by infrastructure construction and dominance of technical aspects.
- 2. Market and environment.** It starts from the first internal market in electricity directive 96/92 – 19 December 1996. This phase means the expansion of energy markets and forming environmental targets and their dominance – Green Deal.
- 3. Optimized balance:** between technology, environment and market rules. A new period starts after black-out in Spain, 2025. It will be aiming at the optimised balance between technologies, environmental targets and competitive market principles.

# Challenges to energy systems

The main challenge is to achieve climate targets, while maintaining the security of energy supply.

The security of energy supply has two main aspects:

- 1. Technical:** Continuous delivery of energy and fuels to the people and the economies – 24 hours per day and 7 days per week.
- 2. Economic:** Energy and fuel prices should be affordable for the public and the economies. It means the economies can operate as competitive and the people are not obliged to sacrifice the basic needs.

# Intermittent and dispatchable generation

- Climate targets require increase of RES production mostly from PV panels and on- and off-shore wind, but such generation strictly depends on weather conditions.
- To fill the gap in electricity production, when RES do not work, dispatchable generation is required to provide continuous supply.
- What should be dispatchable technologies for RES production balancing: natural gas, coal, nuclear or perhaps hydrogen?
- As „dunkelfaute“ can take several days/weeks and usually happens in autumns and winters, so dispatchable power should be equal to maximum demand, serving as power reserves to RES.
- If dispatchable plants are to operate as power reserves for Renewables; should we develop a new market for „power reserves“?

# Keeping power system stable and efficient

- Limited coincidence between renewable energy production and loads, in particular between seasons, indicates a need for energy storage: large scale and long-term storages.
- More and more frequently renewable energy is curtailed by network operators leading to lower efficiency of RES and difficulties to achieve climate targets.
- **Energy storage seems to be a Saint Graal for energy transformation.**
- What storage technologies can be used in power systems to limit the renewable energy curtailment: mechanical (hydro-pumping), chemical (BESS) or hydrogen?
- What market solutions can be applied to increase production of renewable energy preserving security of supply?

# Addressing the challenges

- Energy transformation is entering a new phase, which requires close collaboration between technologies in competitive market environment and the increasing application of information technologies, perhaps also supported by AI.
- **The main target is to increase the supply of clean energy preserving the energy security for the people and the economies.**
- Collaboration between researchers and industry is a vital for reaching the emerging targets.
- The conference: European Energy Market, Lisbon 2025 provides the opportunity for discussions and forming collaborations.