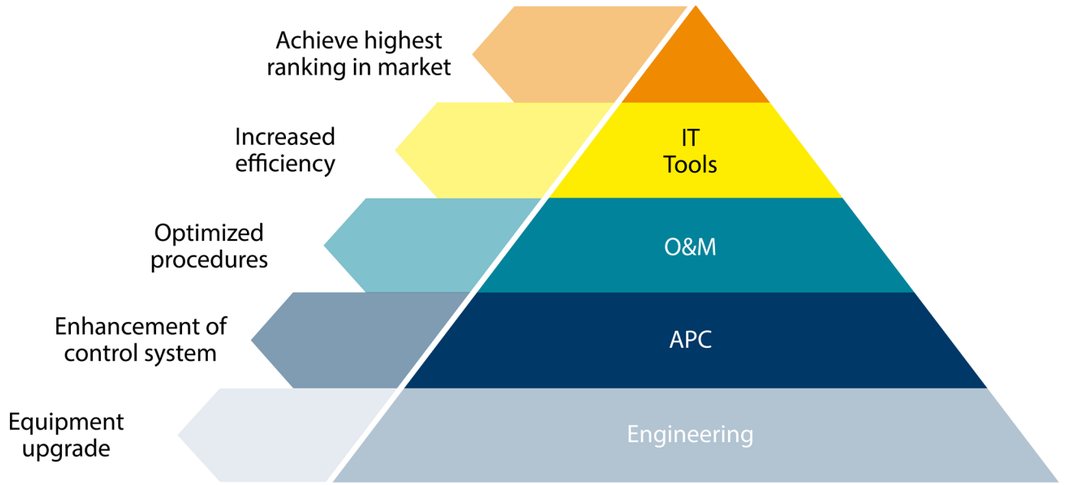



Pyramid of levers to facilitate flexibilisation © STEAG

# Energy Systems of the Future
# Facilitating the energy transition and securing stable and efficient power supply

STEAG Energy Services GmbH

Frequency control reserve from large-scale battery systems and improved flexibilisation of exiting generation schemes help to mitigate increased levels of fluctuating renewable sources to the benefit of grid stability. The described battery project reflects an investment of 100 million Euros into six large-scale battery systems totaling 90 MW in Germany.

## Introduction

The global trend of energy transition results in a tremendous increase of fluctuating power generation by solar and wind energy. Looking on Arabian countries the conditions for solar energy as well as wind are excellent. But there are also challenges to be handled such as misalignment of available renewable power to the peak demand and grid stability.

In our view it is beneficial to review the learnings from Germany's energy transition. The German framework in the generation sector is not the masterpiece, but there are several approaches, which may be adaptable to the situation in the Arabian countries. Today's electricity supply in Germany is decreasingly based on the existence of large central power plants that in the past ensured electricity supply and stability of the grid. As a consequence of the nuclear phase-out and the progressive energy transition, 55 % - 60 % of the German gross electricity demand is to be covered by energy from renewable sources by 2035. The decreasing proportion of energy fed into the grid by conventional power plants and the increasing proportion of fluctuating infeed from renewable energy sources require a flexibilisation of power generation and grid operation, especially in lower-level voltage systems.

## Flexibilisation of Power Plants

Taking into account that even in Germany`s scenario in 2035 fossil fueled power plants will be needed to provide 30 – 50 GW of capacity between 1,500 and 2,000 hours per year, these power plants have to be activated and deactivated quickly, thus resulting in steep load change ramps. In this scenario fossil fueled power plants will progressively be operated in medium load schemes (1,500 – 4,000 h p.a.).

Subject to the individual plant and its specific operation and market environment, there is not one best solution to cope with the multiple challenges. Therefore, it is mandatory to elaborate the customized approach, most economically combining elements of immediate operating expertise, special mechanical and process engineering and innovative software solutions. Identified measures will have to be prioritized with regards to cost and effect to flexibilisation.

Even aged thermal power plants can significantly be improved and operated beyond their initial design. As an example one decade ago nobody could imagine to operate a coal fired power plant at less than 20 % load with stable coal firing without burning auxiliary fuel.

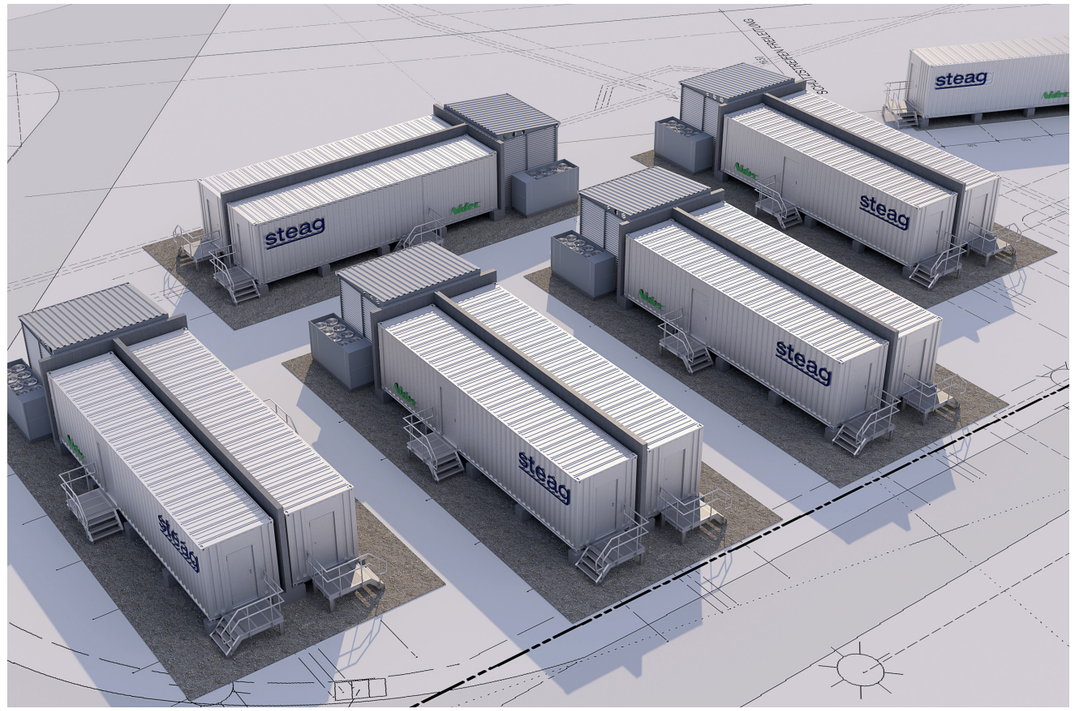
For sure, the measures will become less effective and more difficult to implement the higher you are in the pyramid of levers.

Beyond pure engineering and hardware modifications, digital intelligence like energy management systems supports the operator to increase the efficiency and availability throughout daily operation. Predictive maintenance and early warning systems monitor the process conditions and component health. In addition to this lifetime consumption monitoring systems track the degradation during frequent load changes.

Furthermore, computerized maintenance management systems (CMMS), like STEAG´s SI®/PAM provide support in planning, control, execution and documentation of maintenance, thus ensuring economical strategies for preventive and condition-based maintenance and documentation.


Concept 15 MW large-scale battery systems at Luenen power plant site © STEAG


Augmented Reality 15 MW large-scale battery systems at Luenen power plant site © STEAG




Layout 15 MW large-scale battery systems at Luenen power plant site © STEAG

## Battery Systems and the “Energiewende”

Owing to the framework in Germany´s power sector, priority infeed of electricity from renewables causes conventional power plants to be temporarily squeezed out of the market, whenever the wholesale prices fall below their generating costs. During the resulting shutdown periods the conventional plants therefore cannot contribute to maintaining the system stability of the European interconnected grid. However, the transmission system operators (TSOs) are obligated to constantly take measures to ensure safe operation of the power supply systems. The so-called “system services” include maintenance of frequency stability, monitoring and control of voltage stability, restoration of supply after failures, and operational management. Battery systems are a fundamental element of the energy transition, in particular as a safeguard for system stability and system security, as they are able to contribute to the various system services.

At present in Germany, only the supply of control power for frequency stability is put out to tender on a dedicated market in an open, transparent and non-discriminatory manner. All other system services, such as the provision of reactive power or maintenance of voltage stability are solely requested by the responsible TSO from conventional power plants. To ensure that such system services can likewise be offered by all players participating in the ever more distributed generating environment of the liberalized electricity market, it is necessary for new markets to be established on which the individual system services are put out for tender, similarly to the control energy market. This will enable facilities such as battery systems to be developed for the specific application case and operated profitably.

## The Large-Scale Battery Systems Project

As one of Germany´s major players in the power generation sector, STEAG has gained experience with battery systems for the provision of system services, such as the supply of frequency control reserve, since 2009. One of the first lithium-ion storage units in Germany was approved for grid stabilization service and has been successfully operated at the Völklingen-Fenne power plant site since 2013. Following extensive development work and acquisition of technical know-how, the battery system was prequalified for frequency control service in 2014 and incorporated in the power plant pool for commercial operation.

Based on the experience gained in the research project, an economically viable concept for a battery system with 15 MW capacity has been developed. Apart from the dialog with the transmission system operators about grid infrastructure and the necessary storage capacity, this also included an analysis of the frequency control reserve market and the development of price scenarios for the future. Thereafter, a first business case was created and profitability calculations were performed.

Following a positive assessment of the profitability of a large-scale battery system detailed specifications for a portfolio of six large-scale battery systems were compiled. Then, the technical equipment was put out to tender and the definitive investment criteria were defined. Once the six locations in crucial grid segments had been defined in the states of North Rhine-Westphalia and Saarland the current regulatory framework was clarified with the responsible authorities.

Upon completion of the decision-making and contract awarding process, implementation of the project started. Since battery systems and the creation of flexibility are instrumental in the implementation of the energy transition in Germany, the financing was deliberately structured without drawing on any subsidies, in order to demonstrate that even in the present market situation large-scale battery systems can be profitably operated in the frequency control reserve market. Commercial operation has started at the end of 2016.

In all, large-scale battery systems with a total capacity of 90 MW have been installed at six sites, on a total area of more than 1,500 m². In order to satisfy the current requirements of the TSOs in Germany and provide the required primary control service for at least 30 minutes, each large-scale battery system has a total storage capacity of more than 20 MWh.


Realised 15 MW system at Luenen power plant site © STEAG

The battery cells with highly efficient lithium-ion technology are arranged in containers in order to permit a change of location at a later time. This also helped to minimize the time required for manufacturing and field erection. At each site, a total of 10 battery containers with a capacity of 1.5 MW each, five transformers and one control container have been installed. You may find more information under:
http://steag-grossbatterie-system.com/en/.

## Summary & Outlook

The lessons learned from flexibilisation of power plants and the large-scale battery systems project is manifold. This experience can be introduced into the developments in the Arabian context. STEAG is worldwide examining further applications of storage systems and is open to project proposals and/or cooperations.

As the share of energy from renewable sources continues to increase and, consequently, conventional plants are required to comply, the electricity supply system of the future will need an additional option to provide flexibility. Nevertheless the conventional power plant fleet will still be the backbone of a stable energy system, but various improvements are necessary and possible.

With the described large-scale battery project, it has been demonstrated that battery systems can already today make a substantial contribution to the security and stability of electricity supply systems and can be profitably operated by participating in the frequency control reserve markets.

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Inside the battery container © STEAG