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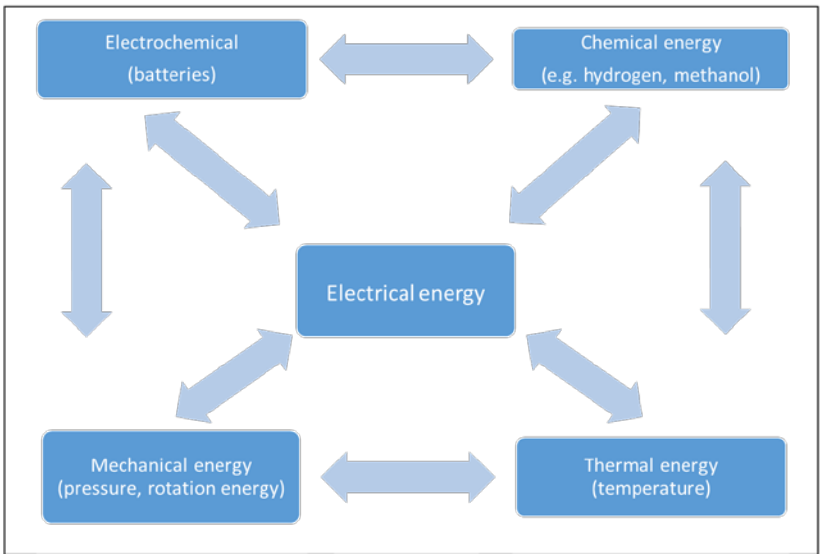
Integration of energy storage in thermal power plants

Thermal power plants, originally designed for base-load operation, are increasingly shifting their role to provide fluctuating back-up power to meet unpredictable and short-notice demand peaks, to control and stabilise the grid. Increasing the flexibility of thermal power generation – by means of incorporating energy storage solutions – will be a key contributor in the future energy system, with an ever-increasing share of variable renewable energy sources.

Energy storage contribution to flexible thermal power plants

When there is a high level of renewable power, energy security can be maintained by making thermal power generation more flexible. The integration of energy storage can greatly contribute to increasing the flexibility of thermal power plants. Energy storage can help thermal power generation optimise its operation by bridging between stop and restart of a generator or by providing the needed time to achieve optimal ramp-up/-down, so that fast load changes can be met – thus, contributing to the targets for thermal power generation identified in the SET-Plan Action 4[i]. These solutions will also contribute to increase the efficiency of thermal power plants – including fuel efficiency, which will be translated into a reduction of CO_2 emissions –, reducing as well the cost of electricity.

Energy storage options: electrochemical, thermal, mechanical and chemical



Energy storage can be simplified into four dominant forms that are interchangeable between each other: electrical, thermal, mechanical and chemical storage. The cost and efficiency to transform between the energy forms is determined by the available technology. The size and duration of the storage also has a large impact on the cost and performance. These factors combine to determine if storage options are available and economically viable to meet power management requirements.

Energy storage can be considered independent of thermal power generation systems, such as battery/PV combinations, pumped hydro storage or renewable fuels for mobility. However, there are unique advantages to combine storage with thermal power generation from a cost and performance point of view. Many components can be re-used by integrating electrical, thermal, mechanical and chemical energy storage into thermal power plants. The possible integration into a gas turbine combined cycle is shown here:

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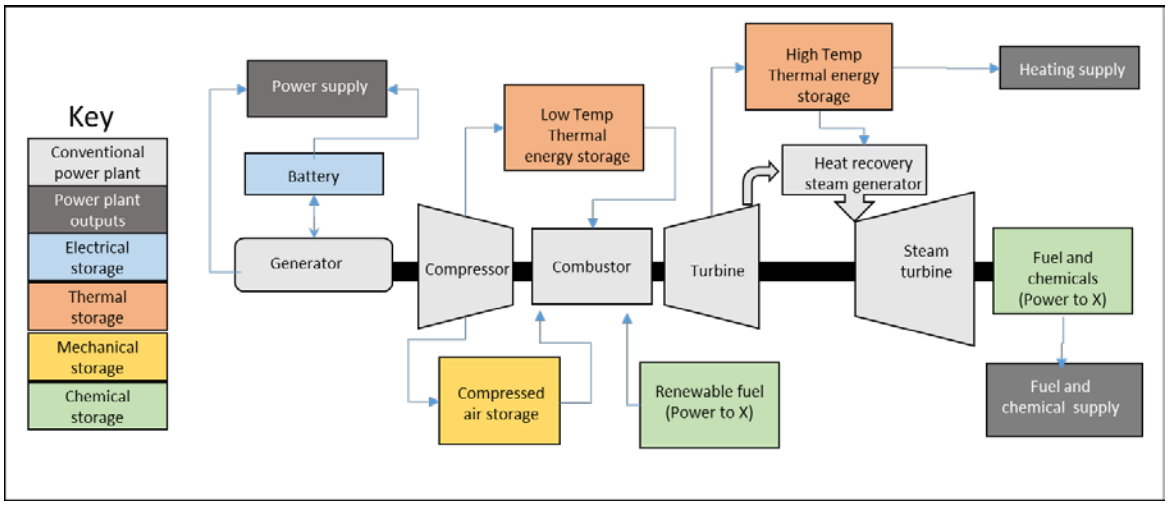
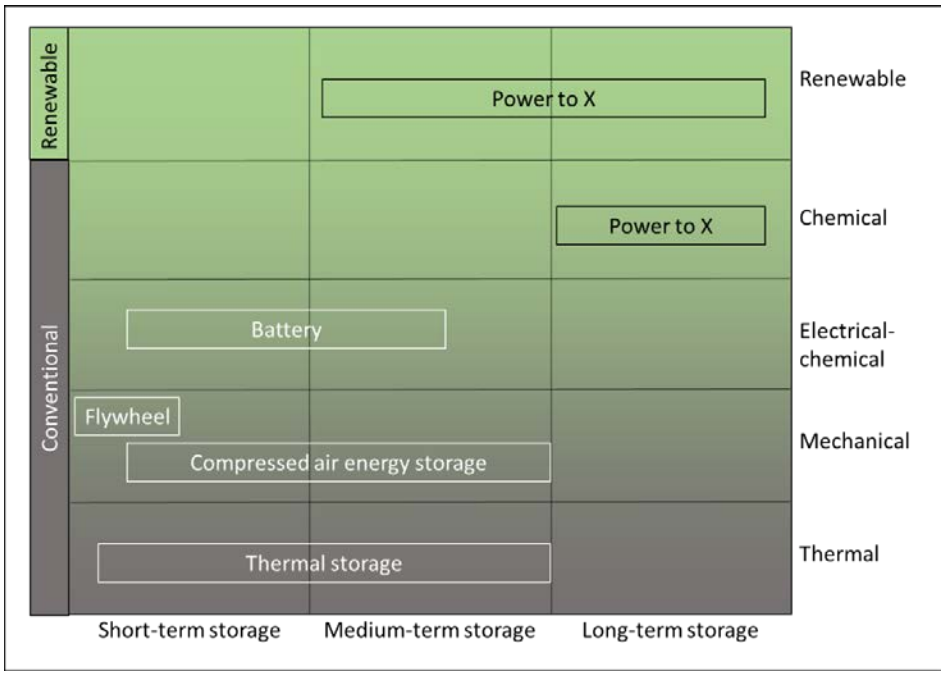


The chart below shows example storage solutions that can be combined with thermal power plants in the short-, medium- and long-term. Solutions are shown in the thermal, mechanical, electrical and chemical areas. For example:

- the compressor and expander of a gas turbine can be used both for compressed air energy storage as well as for the gas turbine,
- a flywheel added to the shaft of a gas turbine does not need a separate generator,
- thermal storage can use the steam turbine in a combined cycle power plant to extract power,
- the expander of a gas turbine driven by external pressurised air can reduce the compressor work and increase the power plant output above the plant maximum,
- a battery added to a gas turbine can be recharged from the available generator when less power is supplied to the grid,
- the fuel generated using renewable energy (Power-to-X) can be used in thermal power plants (X-to-Power) as long as the fuel is compatible with the combustion system,
- stored thermal energy can be used to heat thermal plants to enable faster response rates without damaging components.



[i]The SET-Plan Action 4 Declaration of Intent (Initiative on Energy Systems, p.4) sets up a number of requirements for at least 50% of all thermal power generation to meet the necessary flexibility demanded by variable RES by 2030: doubling the average ramping rates, halving efficiency loses for part-load operations and reducing minimum load by 30% compared to the average of today.