

# Improving Energy Security through Electricity Storage in Open and Semi-Open Markets

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## Overview

The current view holds that increasing variable renewable energy (VRE) share creates a problem for energy security due to the non-dispatchable nature of VRE. Electricity storage is increasingly seen as natural solution to this issue. This paper recalls the four pillars of energy security, of which storage is one of them, and analyses some important framework conditions for independent or economically profitable storage to develop. The theoretical background analysis of the spot and futures market is put in relation to storage. The paper shows under what conditions day-night and seasonal storage can be profitable, and why other forms of storage such as long term strategic storage can for the moment not be profitable. The paper then analyses market conditions of 10 open or semi-open electricity markets and assesses in which of them independent or profitable storage is likely to develop. Thereafter, the paper describes the potential contribution of storage to the ancillary market, focusing on primary, secondary and tertiary power regulation. It shows why hydropower storage without pumping is the least cost solution for the ancillary market. PV-production combined with storage can possibly also be low cost. The paper also shows that regulatory power satisfies both criteria of a classic public good and, hence, ancillary markets and commercial markets should be strictly separated from each other. The paper then touches on the potential to develop an over-the-meter market involving prosumers. It concludes with recommending some measures to favour storage in both, open and semi-open markets.

## Methods

The paper builds on the theory explaining the sources of profitable revenue for storage operators and compares them to the roundtrip efficiencies of different storage technologies. It uses market information of 10 countries with either open or semi-open electricity markets and analyses spot as well as future markets. Different types of storage, e.g. day-night storage or seasonal storage, are being analysed and put in relation with different storage technologies. The theoretical conclusions are illustrated with examples from both, open and semi-open markets. Concerning ancillary storage markets providing primary, secondary and tertiary regulatory power, the paper shows in detail why they should be firewalled from normal commercial storage markets. Concerning over-the-meter trading between prosumers and/or between prosumers and consumers, the paper relates the prosumer to his type of settlement, characterized by both, population density and per capita total final energy consumption. The paper ends with discussing the claim of the “sonnen community” to be the world’s largest virtual power plant.

## Results

Not all storage technologies can be used for all types of storage. Storage technologies with medium or high roundtrip efficiencies can be used on day ahead spot markets where the price spread is sufficiently large. Open and liquid markets in developed countries are in general favourable places for day-night storage. Peru is found to be an open market still too strongly dependent on fossil energy and hence not yet a good place for day-night storage from renewable sources. On the other hand, Vietnam is found to be a semi-open market where storage conditions are surprisingly good. Future markets are important for seasonal storage but their more limited price spread requires storage technologies with roundtrip efficiencies of 80% and higher. Futures markets are usually not found in semi-open markets of developing countries. Even in developed countries, their use in seasonal electricity storage may still be impeded by a lack of understanding. Ancillary storage markets for primary, secondary and tertiary regulation have different objectives than commercial storage markets. Local governments may find a new way to shape their future energy security by setting up and leasing ancillary storage facilities to the transmission storage operator. Concerning over-the-meter trading, the paper shows that the type of settlement of the prosumer, characterized by population density and per capita total final energy consumption, determines the likelihood of a prosumer to be

predominantly producer or consumer, and hence the expected predominant direction of electricity flows. A parametrized table is supplied to illustrate this distinction. The “sonnen community” is found to be the largest virtual power plant under the condition that it combines two local contracts, a condition that is most probably satisfied in open and competitive markets.

## Conclusions

The paper recalls and builds upon the four pillars of energy security, of which storage is one of them. The price spread in liquid open markets of developed countries usually allows for independent or economically profitable day-night storage. In some cases, open markets are not favourable places for day-night storage, whereas in other cases, semi-open markets can allow for day-night storage to develop. Seasonal storage will better develop where a futures market exists. Countries with semi-open markets rarely have futures markets. Ancillary markets operate on different objectives than commercial markets and should be firewalled from the latter. Local governments may set up ancillary storage facilities for lease to the TSO. The direction of over-the-meter-trading by prosumers depends mainly on population density and per capita total final energy consumption of their settlements. The “sonnen community” offers a model for over-the-meter-trading and a virtual power plant in open and competitive electricity markets.

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