

Smart Energy and Smart Grids

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References

- [1] “ÚVOD DO LIBERALIZOVANÉ ENERGETIKY”. Asociace energetických manažerů, 2016. [Online]. Available at: <https://www.mpo-efekt.cz/upload/7799f3fd595eece1fa66875530f33e8a/kniha-trh-s-elektrinou.pdf>

1 Electricity market

All the electricity that flows through electrical power grid was purchased on the electricity market. The basic market participants and their roles are depicted in diagram on Fig. 1.

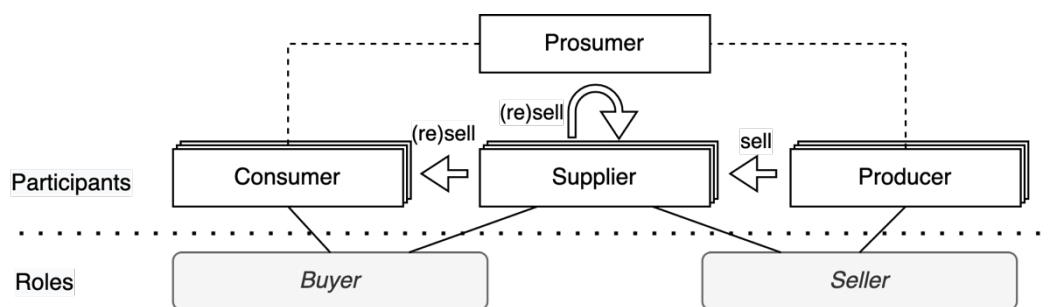


Fig. 1 Trading participants on the electricity market and their roles

The description of the roles is as follows:

- **Producer** – Producer of electric energy. It is most typically **seller**. He can sell energy to multiple suppliers.
- **Consumer** – Consumer of electric energy. Typically has one supplier, which is also responsible for consumers imbalance. It is most typically **buyer**.
- **Prosumer** - New role in EU legislation. Prosumer combines both producer and consumer roles because consumer can also become producer if he has some sort of energy source that can be monetized.
- **Supplier** - The role of the supplier is to concentrate the scattered demand of smaller consumers. Because each of them has a different consumption timeline, the supplier can combine sub-consumption diagrams, which are often very uneven, to obtain a much more even overall diagram for which it is more advantageous to buy electricity on the market. The supplier, besides the delivery, overtakes responsibility for the imbalance on behalf of the consumer and is himself registered as a subject of settlement (see the next chapter for details). Supplier maps to both, buyer, and seller.

There are many different types and organization of energy markets. All the different markets have its specifics. Basic division can be done as follows [1]:

- **Wholesale (trading)** is a business carried out on a larger scale and to secure other business transactions between individual business entities in the market (Business to Business, B2B), i.e. it is not primarily intended for the end consumer. It can be a trade between producers and other traders or a trade between traders themselves.
- **Retail (“sale”)** is a trade carried out to ensure the consumption of the end consumer. It can be trade between producers and end consumers, traders and end consumers, or two traders, one of which focuses on deliveries to end consumers.

The wholesale market can generally be divided according to the length and nature of the supply into three basic energy markets:

- **Long-term product markets** are markets where transactions with the supply of electricity for a period of one month or more are carried out. It can be also called **forward market**.
- **Short-term markets** are markets where transactions with the supply of electricity are carried out in the range of several hours to several days, but for a maximum period of one week. It can be also called **spot market**.
- **The regulatory energy market** is a market where trades are carried out to resolve imbalances between contracted and realized electricity supply and consumption in the electricity system.

Another division of trading can be introduced according to used method:

- **Bilateral trading**, direct or using broker platform. When used directly, an European standard is EFET contract. Usually, the subject of trading is electricity delivery according to agreed consumption schedule (diagrams).
- **Trading using exchange**. Trading can be long-term based or short-term (spot). E.g., Slovak and Czech short-term markets are done using spot exchanges (OKTE, OTE). Long-term trading organizes e.g. POWER EXCHANGE CENTRAL EUROPE (www.pxe.cz)

2 Matching of financial and physical power flow, balancing, regulation

As mentioned in the previous parts, electricity that is delivered from producers to consumers through power grid was purchased on the **electricity market**. So in the energy domain we have two levels of flows, one is **financial** and the other one is **physical**.

Since grid is in general shared resource that needs to be kept in good condition a careful matching of both levels of flows is established. Thus, the agreed and scheduled electricity flows in the financial level are checked against physical flows, whether they are physically produced and consumed according to schedule. This check usually preformed on 15 min or 1 hour basis (**settlement period**).

If the real consumption from some subject differs from the schedule, the subject exhibits **imbalance** and should be punished for this.

Imbalance summed for all subject connected to power grid represents **system imbalance**.

Significant system imbalance may lead to technical problems, even **blackout**.

To make the grid stable, the system imbalance shall be neutralized. The main tool for this is the **regulation energy**.

A grid operator monitors the grid and in case of system imbalances adds positive or negative regulation energy into grid, just to neutralize the system imbalance.

Negative regulation energy means, that the energy is consumed by the negative regulation energy provider.

Lack of energy in grid causes frequency decrease (below 50 Hz) and surplus of energy causes frequency increase (above 50Hz).

Lack of energy is worse and has stricter management. Lack of energy occurs if producers produce less energy as scheduled and/or consumers consume more as scheduled. Surplus of energy occurs if producers produce more energy as scheduled and/or consumers consume less as scheduled.

After the settlement period, the situation is evaluated. Since all schedules are centrally collected by grid operator (financial level) and all producers and consumers have electricity meter (physical level) it is easy to compare these two levels, discover who the sinners are. Schematically the situation is depicted on Fig. 2. The sinner shall pay for the regulation energy that was necessary to keep the grid stable in the corresponding evaluation period.

However, the evaluation is performed against entity called **balancing responsible party (BRP)**. This entity owns balancing group, which is group of consumers/producers for whose **forecasts and dispatches the schedules** for the grid operator and **overtakes the responsibility for their imbalance and their settlement**.

The bigger the balancing group is, the better statistical chances have the BRP that the scheduled production/consumption will be aligned with real production/consumption.

For the end-users, i.e. consumers like households, all the energy purchasing and responsibility for the imbalance usually cover the energy companies, based on the contract with consumer. The consumer just simply pays his monthly bill based on parameters agreed in contract, such as max. consumption, tariffs, daily schedule, etc. and on consumption registered on electricity meter installed at connection point.

Connection point is the place, where the subject is connected to the power grid.

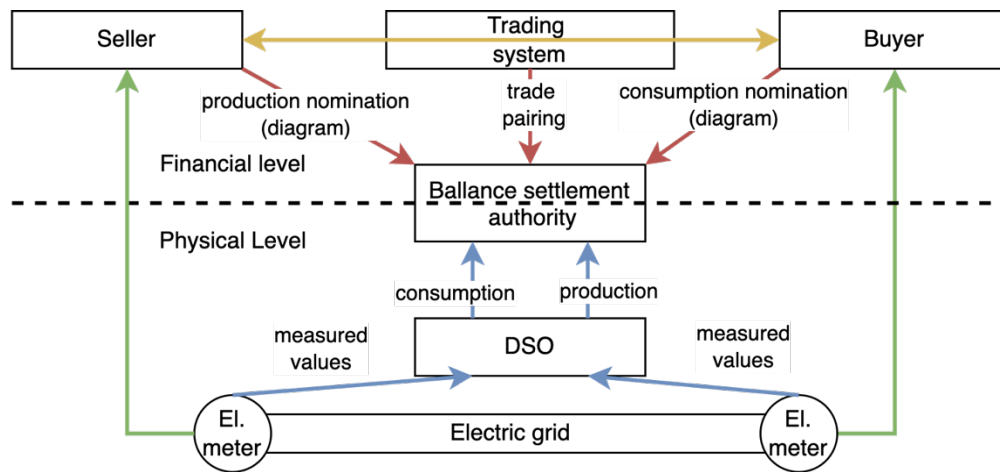


Fig. 2 Principle of financial level and physical level pairing and imbalance computation