A marketplace for energy

The energy grid is becoming increasingly complex: decentralized energy producers require storage possibilities, such as large stationary batteries, to guarantee our power supply even with an increase in heavily fluctuating energy sources like solar and wind power. A project at Empa’s research and technology platform ehub (Energy Hub) is analyzing how energy flows can be regulated intelligently and in real time.

TEXT

Switzerland’s power supply is on the brink of a major transformation: instead of a few large-scale power plants, a growing number of small, decentralized producers are feeding electricity from biomass, wind power and photovoltaics (PV) into the grid. Especially in wind power and photovoltaics, the amount of energy that is fed in is subject to heavy temporal fluctuations depending on the weather. Storage devices are used to keep the grid stable and guarantee an uninterrupted power supply. This makes the power grid of the future far more complex: instead of centrally regulating the major power plants in such a way as to produce just as much energy as is needed, the decentralized generators will have to store energy at times when it is not required. To maintain the equilibrium between numerous extra energy suppliers and storage systems on the energy grid and avoid overexerting the power lines, energy flows have to be optimized by means of “smart” regulation.

In a project at Empa’s energy demonstrator in Dübendorf, researchers are now testing a new possibility to combine the grid, power suppliers, consumers and storage systems in a smart way on an urban district

level. The goal is to find out how renewable energy can boost the grid’s stability and

be exchanged between districts in an optimum way.

The idea, developed at EPFL in Lausanne, involves viewing the power grid as a trading floor of sorts: every participant can offer or request energy with a desired price tag attached. An intelligent control system manages energy flows in such a way as to minimize the overall costs of the system.

How much does it cost to charge?

Take the example of a stationary storage battery: if it is fully charged, it doesn’t make much sense to pump in more electricity – so charging the battery even more becomes expensive in this “energy marketplace”. At the same time, the battery serves as an energy source – drawing energy becomes cost-effective. Once the battery charge has dropped to a few percent, however, it will be cost-effective to re-charge but expensive to discharge. In this energy marketplace, every participant has their own agent, irrespective of whether they are producers, consumers or storage systems. This agent translates the device’s current needs into a common language and forwards this information to a hub, which is responsible for a sub-grid. This hub has its own intelligence: it monitors the grid, collects the needs and offers from all participants in “its” sub-grid and calculates how the energy flows ought to be conducted ideally – at a rate of ten times per second. A neutral energy exchange has thus been created.

This also allows special circumstances to be taken into account: if electricity production fluctuates heavily in a short period of time, for instance, it makes more sense to charge and discharge a supercapacitor instead of straining a battery with numerous charging and discharging cycles, which would age it quite rapidly. In this case, the cost of charging the battery is considerably higher than charging the supercap – and so the energy will flow to the latter.

Flexible and freely expandable

One advantage of the idea is that the system can also be expanded flexibly in future: if new storage possibilities, producers or consumers join, they merely require their own agent to translate their needs and offers – and they are already part of the energy marketplace. Empa is testing this concept in ehub’s energy system. The energy demonstrator, which supplies the research building NEST and the mobility demonstrator move with energy, combines thermal and electrical energy components. These include a photovoltaic plant, heat and cold storage units, a hydrogen cycle, heat pumps and supercondensers as well as batteries, which are combined with each other in various grids. Each of these sub-grids is regulated by its own hub.

In future, the system should also work on a larger scale. And the researchers have already worked out how: in a district, a hub combines the resources available and the sub-grid it monitors into a virtual resource with a single, “accumulated” cost function. The next hub on the level above would thus receive rather simple information. Not only could such an energy marketplace include individual districts, but also cities, regions or even the whole country. //

COMMELEC - arranging energy sources and storage facilties in a virtual marketplace. (EPF Lausanne)  
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