USING ELECTRICITY AS THE WIND BLOWS

More renewable energies are good for the environment but we will need to be more flexible and use electricity as the wind blows.

We all use and need electricity, from the moment we wake up until we go to sleep. We are experiencing an electrification of everything. A few decades ago all kitchen tools were human-powered and today they are almost all electric. The vehicles we use today are powered by fuel but we are now introducing more and more electric vehicles. We are all aware when we take the car that it contaminates; we can actually see the smoke coming out of the exhaust. What we are not as aware of is how pollutant is the electricity we use...

We are trying to decrease the overall pollution by having more renewable energies: more wind parks, more solar panels, more hydropower... For example, the Danish Government has set very ambitious goals on the implementation of renewable energies. In 2025, 50% of the electricity we will use in Denmark will come from renewable sources. In 2050 Denmark will be all powered by renewables. Most of the people will think: "Look how cool are these Danes, they really care for the environment". But not all the people will ask themselves: "What will happen if there is no wind and no sun? How are we going to get the electricity we need?"

More renewables are good for the environment but raise some challenges we did not had before. The grid operator has the responsibility of ensuring that we produce all the electricity we consume, nothing more nothing less. Until now we adapted the production to the needs of the consumption: more electricity needed more fuel into the power plants. In the future electrical grid this paradigm will be the opposite. We will need to consume all the electricity we produce; we will need to use the electricity as the wind blows. We will need to be more flexible on how we use electricity.

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The technical word for this flexible electricity consumption is demand response.

Size does not matter (if you aggregate)

Where can we get this desired flexibility from? Industrial and commercial consumers are very attractive from a flexibility point of view. They have high and centralised consumption, thus with not much investment on equipment we can control the electricity consumption there. On the other hand, the electricity consumption in one household is very little. But if we consider the whole residential sector it still accounts for a big part of pie. Why should we discard this flexibility source?

The grid is not interested on the flexibility consumption of a single household: the cost of the equipment installed is too high for the small flexibility one house can provide. However, if we can aggregate the flexibility of several homes the story is quite different. How can we do this aggregation? Here is where the concept of a virtual power plant comes into play. A virtual power plant is not a physical power plant; it is a virtual aggregation of electricity generation units, storage systems and controllable loads. The good thing about a virtual power plant is that it operates all these energy resources as if they were one single unit. The idea is that we can use a residential virtual power plant as a system that can aggregate flexibility from several homes and make consumption more flexible. We should be aware that in the future not consuming electricity, or providing negawatts (negative Watts), may be as profitable as generating electricity.

Applying research in a 12-storey living lab in Aarhus

In my research I want to design and also make a prototype of a residential virtual power plant. This system should provide this desired flexible consumption to the electric grid. This can be done in many different ways. The system may decide to turn off the heating while you are not home. Or maybe it will propose you to delay the execution of the dish washer for one hour because the electricity is very expensive.

The system needs to interact with both the electrical grid and the homes. In the grid side, the system shall know what are the electricity prices and if some flexibility is required. In the home side, the system needs to know what is going on in your home: Can we switch off the heating now? Do you want to run the dishwasher? Also in the home side, the system should provide recommendations on electricity usage to the residents but also automatically control some appliances like heating system, washing machine, dishwasher... All these can be done by installing home automation equipment.

We are applying our research in one of the best test beds worldwide. We do not need to go very far to find this unique facility, this test bed is a new student residence placed in the harbour of Aarhus. We call it Grundfos Dormitory Lab but the 180 students living there call it Grundfos Kollegiet. If you look at the building it look like any other new building in the area, but it is not. This building is equipment with more than 3,500 sensors reporting data on the building operation.

We expect that our research will help to know how we can aggregate residential electricity

flexibility but we will also provide an estimation on how much flexibility we can gain from residential consumers.

Contact:
PhD student Sergi Rotger Griful,
srgr@eng.au.dk