Decentralized Energy Management Algorithms made to fail

Studies: BSc Technical Computer Science

The energy transition requires us to rethink how we produce, distribute and use electricity as we rely more and more on weather conditions. For the last 2 decades the “smart grid” paradigm has been the keyword to allow for such a shift, enabled by both the Internet and emergence of Embedded Internet of Things devices. However, as we start to make our electricity usage “smart”, we also start to rely on the proper functioning of this digital subsystem for our electricity supply. That is, the digital system forms an additional weak spot to perhaps the most essential aspect of our modern society. This was particularly clear with the massive blackout last year on the Iberian peninsula (Spain and Portugal).

What we see is that many “smart energy systems” rely on centralized systems, that heavily depend on availability of compute power and communication systems. Currently, many experts warn for the risks of such a centralized system, especially with present day geopolitical tensions. But also in practice we have experienced that such systems regularly fail (e.g., in field tests as part of research projects).

As a result we wish to explore a radical new approach that “embraces” Murphy’s Law instead: Energy Management Systems are doomed to fail anyways, so why not design new algorithms designed to tolerate failure by design? The general idea here is that the electricity grid is basically a mesh network of billions of interconnected devices. If we decentralize and/or distribute the decision making, then failure of one (or a few) devices has little effect on the power system at large, and thus does not impact the general availability of the power system, i.e., power supply remains uninterrupted for most customers.

Assignment
We are just exploring this research direction, and we are curious to explore what is possible to perform energy management in mesh networks. With energy management we specifically mean the coordination (optimization) of energy use for future time intervals between different devices in a network. Possible directions (see also the research questions below) are algorithm convergence, robustness ot failure, and simulating cyber attacks. An interesting video that also showcases the power of networks, with strong resemblence to the physical grid structure, was recently published by Veritasium. This video explains the basis for what we believe might be a robust solution for energy management: https://www.youtube.com/watch?v=CYlon2tvywA

Possible Research Questions:

- How many nodes can fail before the power system becomes instable?
- What happens to the set of nodes if the communication topology changes?
- How fast can an Energy Management System converge using distributed optimization compared to centralized optimization?
- Which protocols, e.g., gossip based, and frameworks are suitable as basis for an such an Energy Management System?

But feel free to reach out if you have other ideas based on this descirption!

Work Division

- Literature: 20%
- Modelling: 20%
- Coding: 20%
- Evaluation: 10%
- Writing: 20%

Contact:

Gerwin Hoogsteen, g.hoogsteen@utwente.nl, Room: ZI-5046