Study Committee D2

Information Systems and Telecommunication

Paper 10414_2022

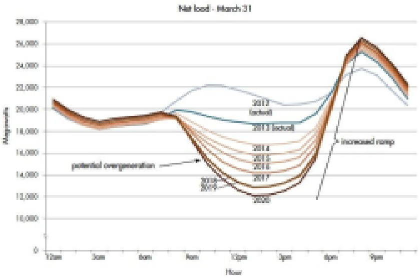
SECURELY IMPLEMENTING AND MANAGING NEIGHBORHOOD SOLAR WITH STORAGE AND PEER TO PEER TRANSACTIVE ENERGY

Steven KNUDSEN[1], Subir MAJUMDER[2], Anurag K. SRIVASTAVA[2]

[1] KeyLogic Systems, Inc., [2] West Virginia University

Motivation

- Reduce California ‘duck curve’ implications using neighborhood energy storage resources. See Fig. 1, to the right
- Control algorithm is needed for “peer to peer” on grid edge, with minimal control from the utility
- Cost analysis also need to be performed for best possible strategies for storage integration
- Need to consider different types of energy storage resources include battery electric storage systems (BESS) with lithium or vanadium redox chemistries
- Customer interactions are secured based on a “zero-trust approach”



Case	Cost ($)	Discount rate (%)	Payback (years)
1: Solar panel on home	10,212	8	6
2: Add BESS to Case 1	22,212	5, 8	14, 20
3: Community Energy storage	>100,000	5	<6 as goal

Case Study: Cost and payback data

- We examine three strategies as case studies to facilitate the policymakers making the recommendation :
  - i. single home with solar power
  - ii. single home with Solar power and BESS
  - iii. two or more homes with solar power and community energy storage.
- Table 1 shows case studies with cost-benefit analysis

Method/ Approach

- Transactive energy concept where prosumers control generation and storage near the grid edge.
- We utilize a peer-to-peer (P2P) transactive approach for the information sharing and optimization
- The technical target of our research is a conceptual design of a DC-coupled solar + battery energy storage system (BESS) with P2P control

Discussion/Conclusion

- Community storage would work particularly well in sunny locations such as California, Colorado, or Arizona
- A more extensive storage system provides voltage/frequency regulation service for the neighborhood and may receive payments from the utility or market for this service
- A P2P transactive energy architecture, where the neighboring customers exchange resources via a DC-coupled network while still being connected to the AC grid, has been proposed in this work
- The need for DC coupling arises due to increased penetration of behind-the-meter solar PV, substantial presence of DC loads within the customer premises, and AC/DC conversion efficiency

Study Committee D2

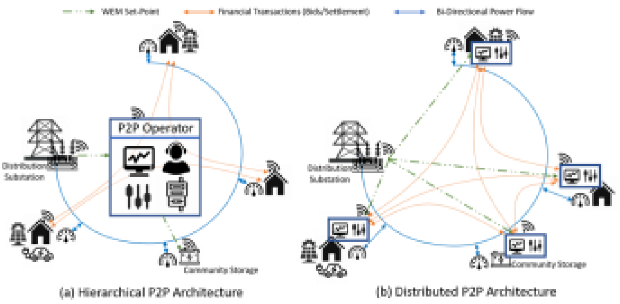
Information Systems and Telecommunication

Paper 10414_2022

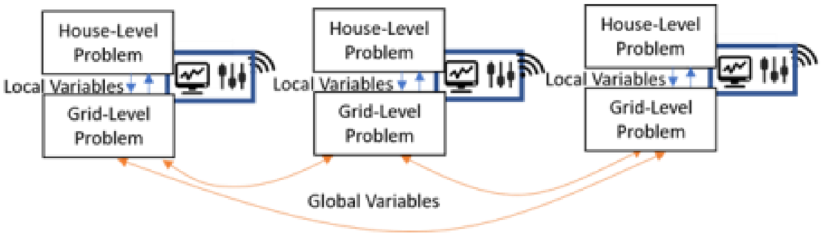
SECURELY IMPLEMENTING AND MANAGING NEIGHBORHOOD SOLAR WITH STORAGE AND PEER TO PEER TRANSACTIVE ENERGY

continued

Transactive Energy for promoting renewable energy integration



- *Transactive energy takes markets and negotiation to the grid edge*
- *Consumers are now prosumers, managing their EVs, microgrids, virtual power plants (VPPs), or other assets*
- *Residential customers, with excess resources and storage devices or share and manage storage devices at the community level among each other in an economical fashion*
- *Multiple neighboring customers would like to interconnect their DC system due to the enormous efficiency advantages of DC-coupled systems*
- *The grid edge can be reasonably secured due to its remoteness and relatively small scale*



Optimization approaches

- The grid-level problem interacts with the house-level problem through the local variables (primal and dual variables of the optimization problem)
- Each of the houses comprises specific devices that require the provision of discrete set-points, while some of the devices would require continuous decision variables
- House level loads could be completely isolated, if necessary. Therefore, house-level problems can be of mixed-integer problem formulation.
- The homeowners (via their edge devices) should decide whether it’s acceptable for them to transfer energy over the P2P DC system or to/from the grid
- Simulation (for CBA) written in C++ programming language showed how energy storage can divert energy from solar panels for later dispatch in the evening

Extended Applicability

- Multiple scenarios, such as outages due to storms or cyber-attacks, with stochastic values for network connectivity, could be addressed

References

- “Confronting the Duck Curve: How to Address Over-Generation of Solar Energy, https://www.energy.gov/eere/articles/confronting-duck-curve-how-address-over-generation-solar-energy, Oct. 12, 2017.
- N. Atamturk, “Transactive Energy: A Surreal Vision or a Necessary and Feasible Solution to Grid Problems?” California Public Utilities Commission, Tech. Rep., 2014
- Knudsen, Steven, Code repository for Solar-BESS P2P simulation, https://github.com/BarkFace/DuckCurve, initiated 1/9/2022