RDGs: Renewable Distributed Generators

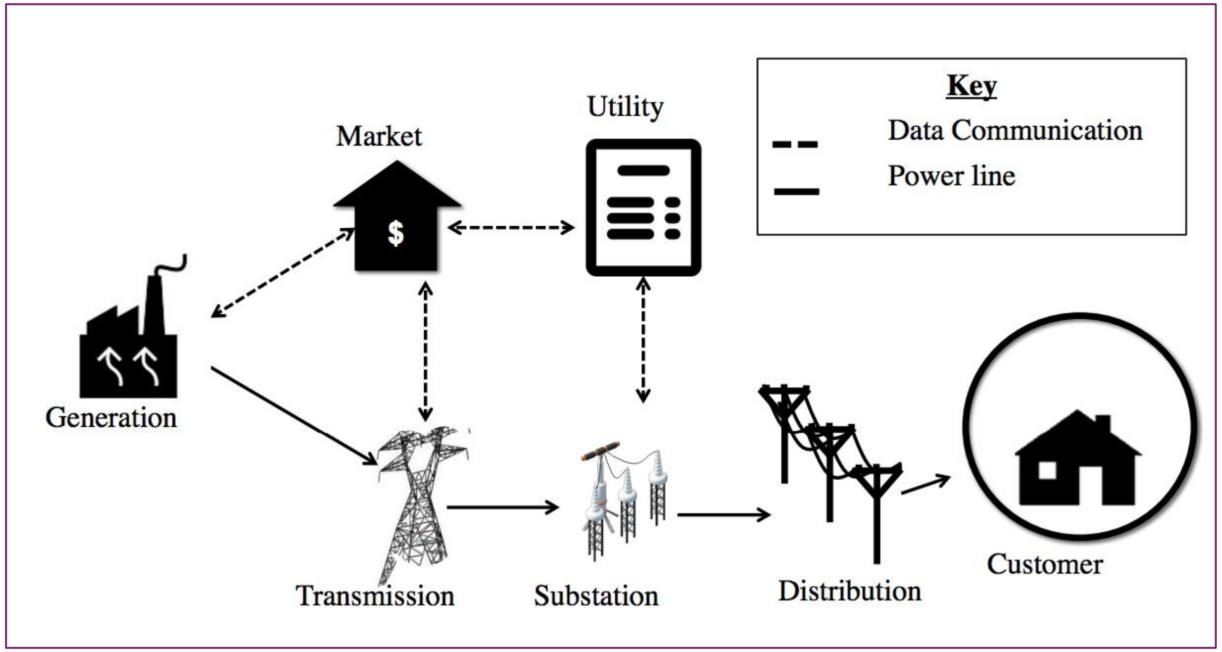
Developed by Stanford University

Technology Summary

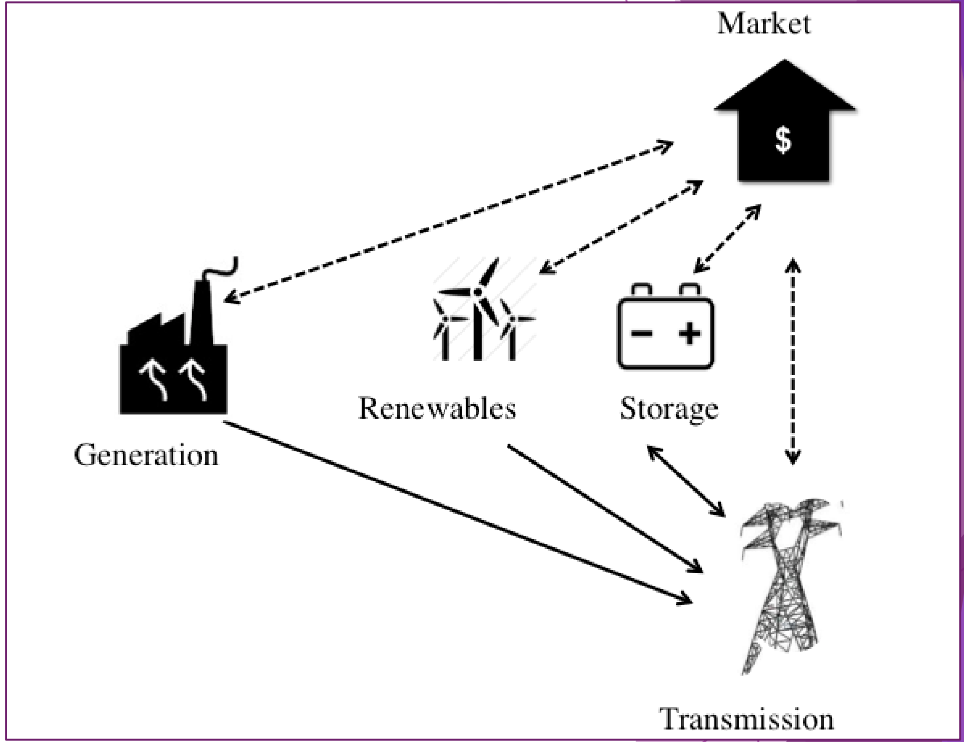
- Architecture and control scheme for the coordination of distributed energy resources (DER), such as solar and storage, to minimize operation cost and enhance network reliability and provide DER aggregation.
- **This scheme simultaneously optimizes energy arbitrage and reduces energy cost by distributing control between a global controller (GC) and local controllers (LCs), shifting more responsibility for control decisions to the local controllers.**
- Win-win relationship between the utility companies who may provide the global coordination and the DER providers who may provide the local control.
- Low loss interconnects to attain efficient signal distribution.
- Potential to increase capacity of short range (chip-to-chip or board-to-board) to medium range (rack-to-rack) communications links

Legacy Grids vs. Smart Grids

Legacy Grid

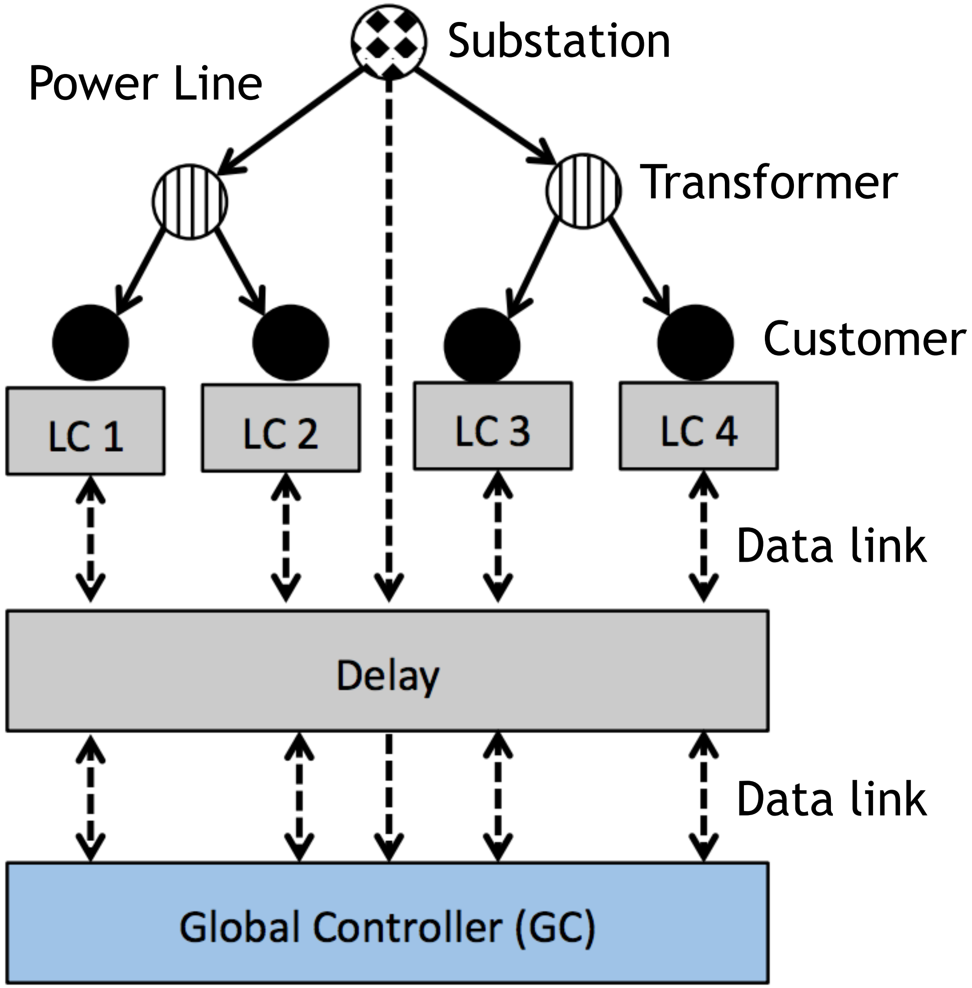


Smart Grid



Smart storage provides (i) shifting the load through **energy arbitrage (EA)** by charging during off peak hours and discharging during peak hours; (ii) providing **regulation service (RS**), (iii) **increased grid security** by providing emergency power during outages; and (iv) **intermittent renewable generation**

Stanford Technology



The method:

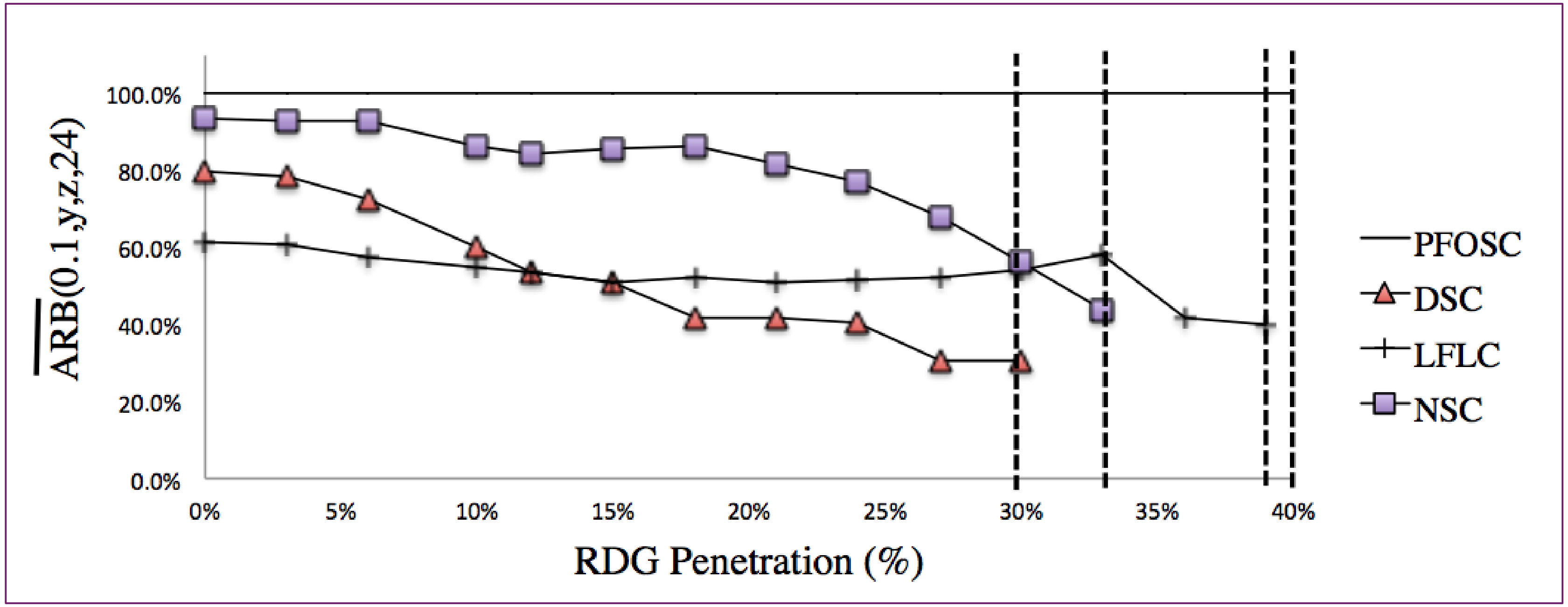
1. Control distributed between a global controller (GC) and Local controllers (LCs).
2. The GC has access to the network model as well as readings from the grid.
3. The GC solves a global optimization and distributes the results to the LCs.
    - However, data inputs/outputs are delayed: GC is restricted in operation
4. The LCs have access to live local data that is not available to the GC (at last global optimization).
5. LCs apply charging actions to the storage based on their live data and information received from the GC
6. The LCs can be implemented as a software process running on the embedded systems already inside the storage unit or the smart meter.

Advantages

- Increased efficiency and balanced load decreases outages, and increases profits
- Faster and more robust – high delay tolerances makes the system less vulnerable to communication network failures, and reduces the need to upgrade the smart meter infrastructure to provide faster data propagation
- Improved efficiency and profitability
    - For eg: in our live-load study, We find that Nodal Slack Controller (NSC) and Net Load Following Controller (NLFC) increase the supported maximum solar penetration to 29% and 40%, respectively, as compared to 10% for Direct Storage Controller (DSC). Moreover, NSC is able to capture 90.7% of the available arbitrage profits which is significantly higher than that achievable with NLFC and DSC

Anderson, Kyle, Ram Rajagopal, and Abbas El Gamal. "Coordination of Distributed Energy Storage Under Spatial and Temporal Data Asymmetry." IEEE Transactions on Smart Grid(2017)

Results: Arbitrage Profit Generation



Arbitrage profits vs. the RDG penetration for the three control schemes for with storage penetration x = 10%. Each plot ends at the maximum RDG penetration achievable by the corresponding control scheme. Arbitrage profit degrades as RDG penetration increases. The NSC scheme performs best in limiting the degradation for a given RDG penetration except at the highest penetration levels. The LFLC scheme is able to support higher RDG penetration levels for the chosen ΔGC. For higher values of delay, the NSC scheme significantly outperforms LFLC in capturing arbitrate profits as noted earlier.

Market Size for Smart Grids

CAGR 19.4%

Global
$50.65 Billion
by 2022

Market Segmentation & Drivers:

Biggest Market Segments

- Software
- Hardware
- Services

Market Drivers

- Government policies and legislative mandates
- Regional government initiatives for smart meter roll-outs
- Increasing demand for integration of renewable energy sources
- Improved grid reliability and efficient outage response

Markets and Markets, March 2018/https://www.marketsandmarkets.com/Market-Reports/smart-grid-market-208777577.html, July 2018

The Team

Ram Rajagopal, Ph.D., Lead Scientist

- Associate Professor of Civil Environmental Engineering, Sanford University
- Electrical Engineering, Ph.D., University of California, Berkeley
- Research interest: sensor networks, power systems, and data analytics

Kyle Anderson, Ph.D.

- Research Engineer, Stanford University
- Smart Grid Modeling, PhD. Stanford University
- Cofounder of Rockset; expertise in storage, data management

Abbas El Gamal, Ph.D. – Principal Investigator

- Hitachi America Professor in School of Engineering, Stanford University
- Member of the U.S. National Academy of Engineering

Desired CEO/Entrepreneur Profile

- Global experience in electrical power distribution
- Experience in smart grids, energy optimization, feedback control or relevant area.
- Previous experience in technology transfer and startup team building
- Previous startup or fundraising experience.