Valuation of Distributed Energy Resources in Transactive Energy Markets

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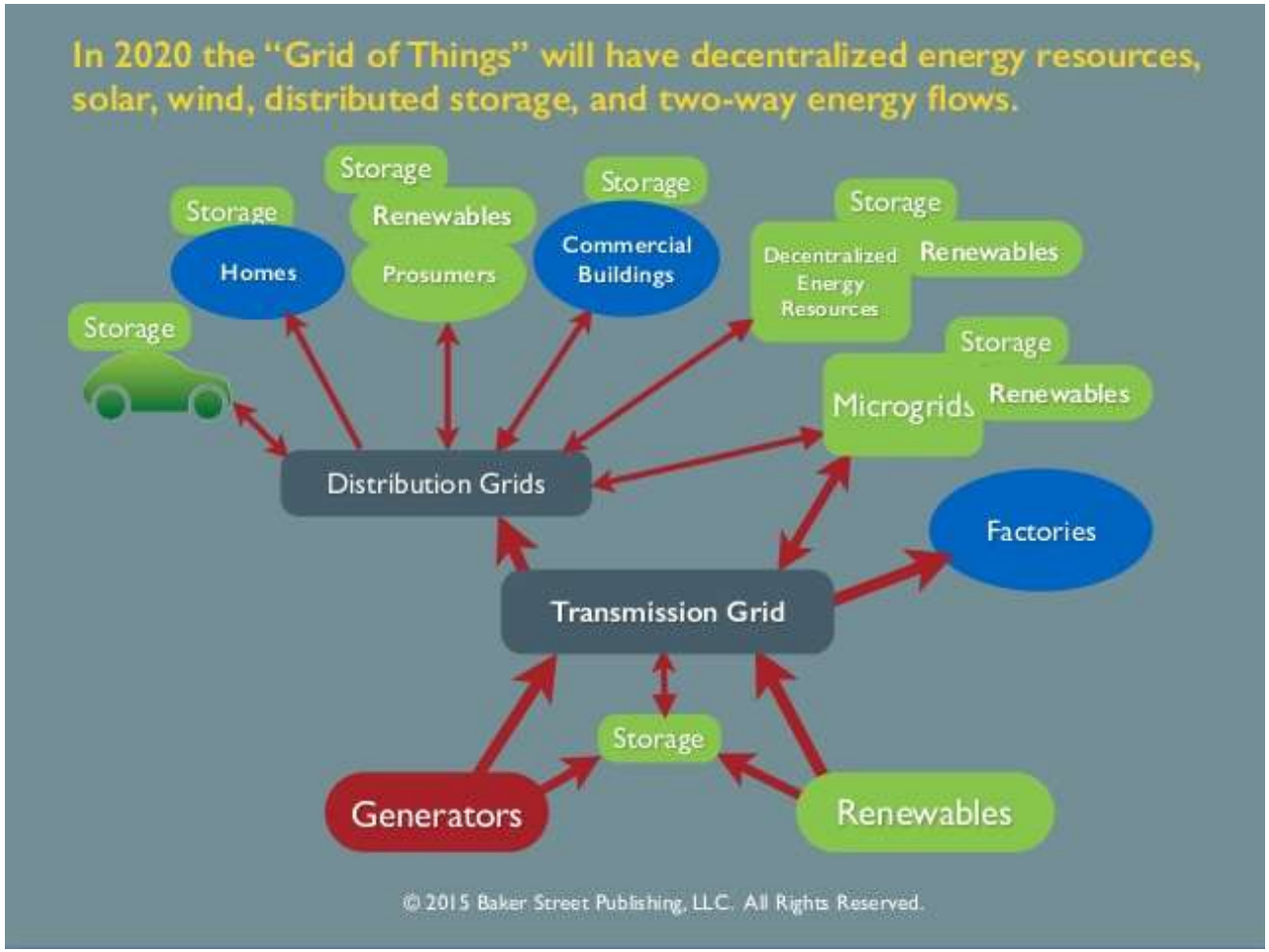
Agenda

- Introduction
- Methodology & Software Simulation
- Case Description
- Impacts
- Results and Discussion
- Conclusion
- Contributions of team members

Introduction

- Definition from NIST for TE: "a system of economic and control mechanisms that allows the dynamic balance of supply and demand across the entire electrical infrastructure using value as a key operational parameter"
- More than 14 million electric consumers are supplying power back to the grid
- Distributed solar capacity has nearly doubled from 7.3 GW in 2014 to 13.8 GW in February 2017
- More than 16 million customers participate in wholesale or utility demand response programs


In 2020 the "Grid of Things" will have decentralized energy resources, solar, wind, distributed storage, and two-way energy flows.
Storage
Storage
Renewables
Prosumers
Storage
Commercial Buildings
Storage
Homes
Storage
Decentralized Energy Resources
Renewables
Storage
Microgrids
Renewables
Distribution Grids
Factories
Transmission Grid
Storage
Generators
Renewables
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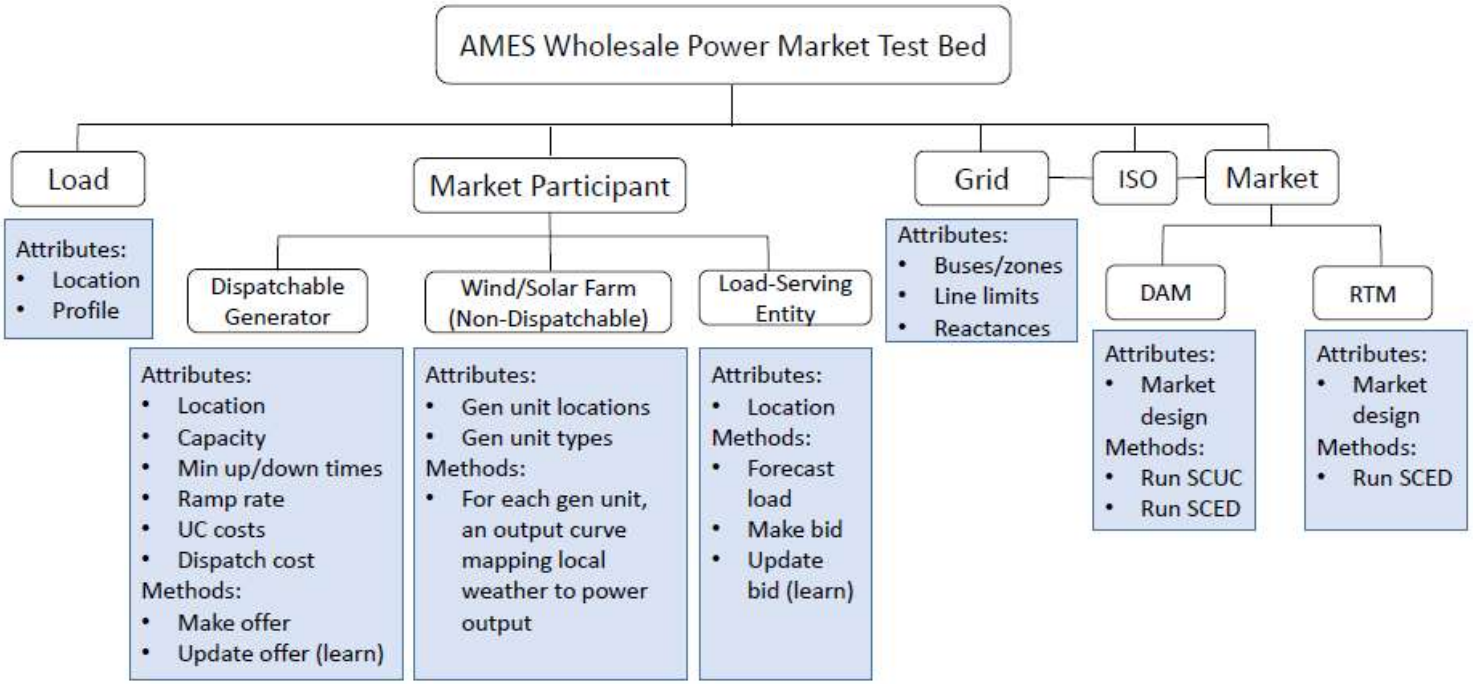
Transactive Energy – How is value added?

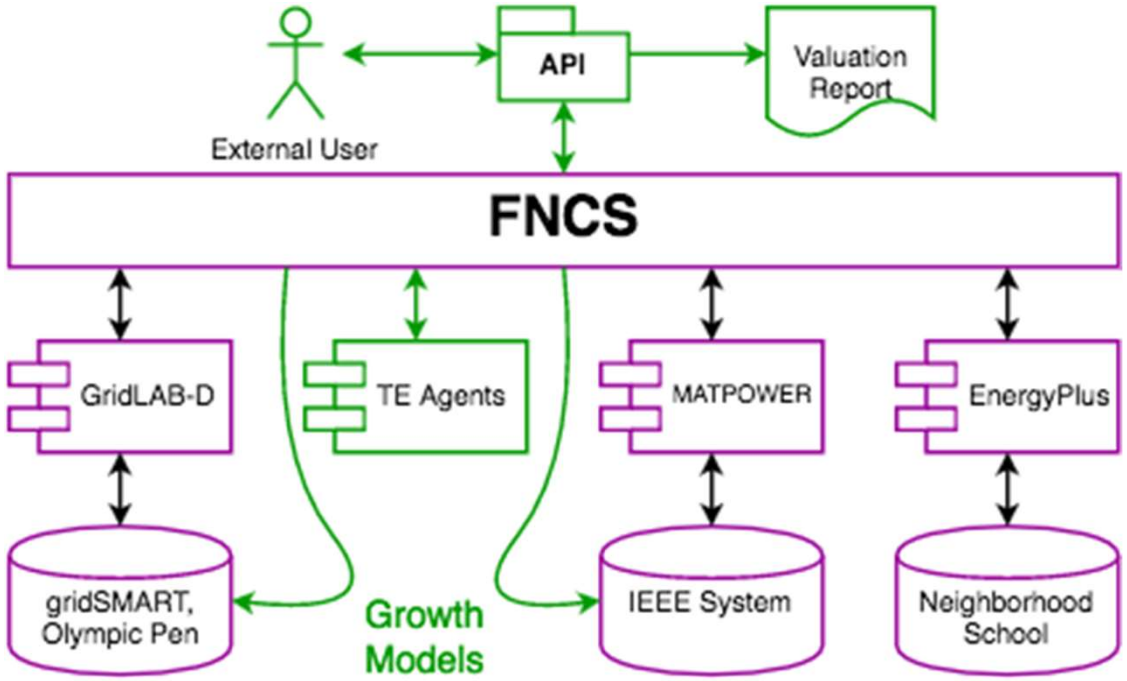
Affordability – forward pricing structures enable customer-side investments, new IT provides automation and can lower cost

Reliability – with incorporation of new functions and controls, greater local and customer control possible

Sustainability – societal benefits from large-scale clean DER adoption

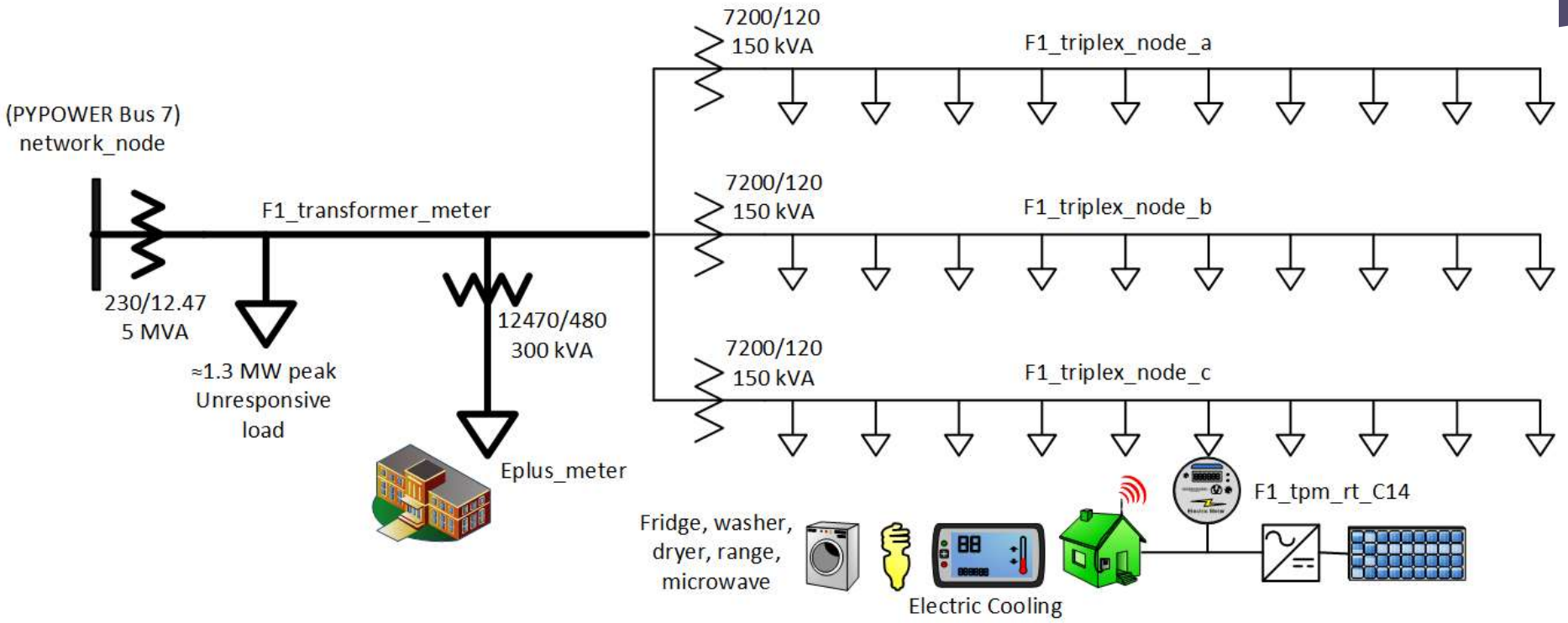

GridLAB-D


AMES Wholesale Power Market Test Bed
Load
Attributes:
• Location
• Profile
Market Participant
Dispatchable Generator
Attributes:
• Location
• Capacity
• Min up/down times
• Ramp rate
• UC costs
• Dispatch cost
Methods:
• Make offer
• Update offer (learn)
Wind/Solar Farm (Non-Dispatchable)
Attributes:
• Gen unit locations
• Gen unit types
Methods:
• For each gen unit, an output curve mapping local weather to power output
Load-Serving Entity
Attributes:
• Location
Methods:
• Forecast load
• Make bid
• Update bid (learn)
Grid
Attributes:
• Buses/zones
• Line limits
• Reactances
ISO
Market
DAM
Attributes:
• Market design
Methods:
• Run SCUC
• Run SCED
RTM
Attributes:
• Market design
Methods:
• Run SCED



Transactive Energy Simulation Platform

Zoomed in view of a typical section in an electrical network



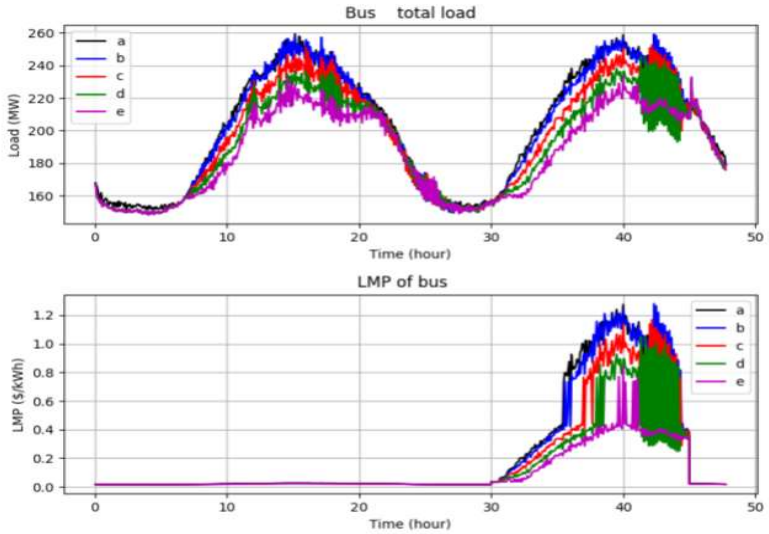
Selected network for simulation

Case Description

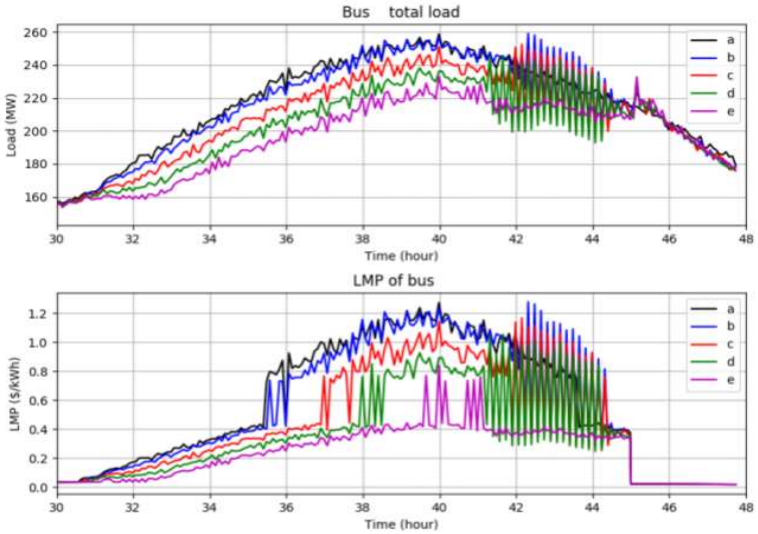
- Case a = base case
- Case b = Case a + 755 TE controllers for HVAC
- Case c = Case b + add 10% PV and 5% battery storage
- Case d = Case c + additional 10% PV and 5% battery storage
- Case e = Case d + additional 10% PV and 5% battery storage

Case	Houses	HVAC Controls	Water Heaters	PV System	Storage System
No TE	1594	1	1151	0	0
Year 0	1594	755	1151	0	0
Year 1	1594	755	1151	159	82
Year 2	1594	755	1151	311	170
Year 3	1594	755	1151	464	253

Impacts on the transmission system



Total Load and LMP at Bus

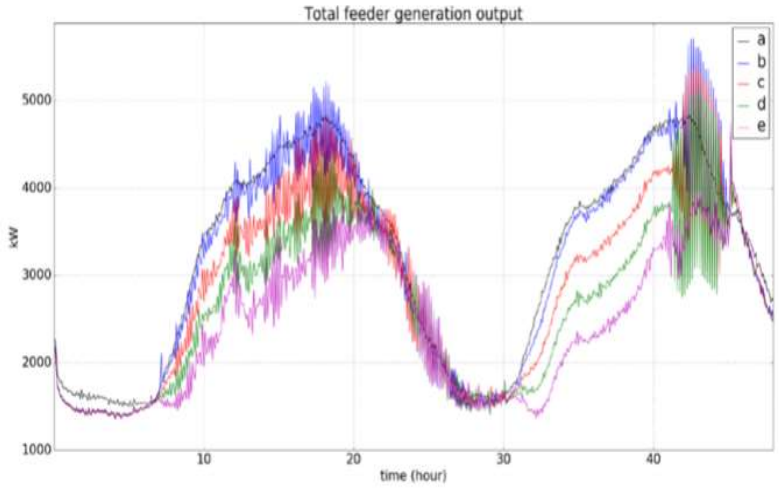


Total Load and LMP at Bus During 30-48 Hrs.

Case	LMP Avg ($/kWh)	LMP Max ($/kWh)	LMP Min ($/kWh)
a	0.220	1.275	0.016
b	0.213	1.280	0.016
c	0.176	1.169	0.016
d	0.145	1.051	0.016
e	0.101	0.839	0.016

Statistics of LMP at Bus

Impacts on the distribution system



Total Feeder Load by Case

Case	Total Feeder Electricity (kWh)	Total Residential Energy Consumption (kWh)
a	154129	141645
b	150063	137677
c	138897	137640
d	128496	137623
e	118157	137632

Total Electricity Consumption by Case

Impacts on the customers

Case	Total Billed (USD)	Electricity Bill per Customer (USD /customer)
a	19158	12.02
b	18653	11.70
c	17265	10.83
d	15972	10.02
e	14687	9.21

Electricity Bills of Customers on One Feeder by Case ID

Case	Total Billed (USD)	Electricity Bill per Customer (USD /customer)
a	-	-
b	-	-
c	2733	24
d	3782	68
e	3137	66

Battery Outputs and Revenue by Case ID

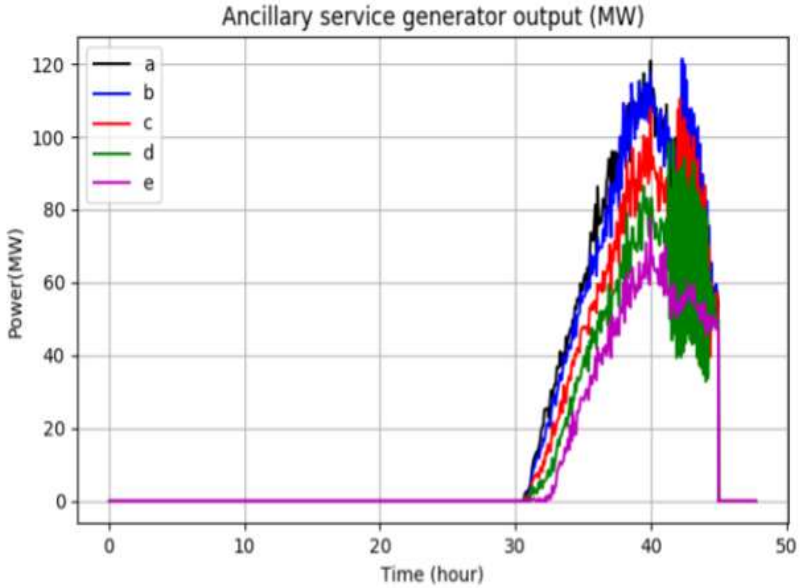
Case	Total Billed (USD)	Electricity Bill per Customer (USD /customer)
a	-	-
b	-	-
c	128438	3325
d	250468	5172
e	373898	5203

PV Outputs and Revenue by Case

Impacts on the generators

The Total Operation Costs, Revenues, and Profits of the Bulk Generators by Case

Case	Operation Cost (M$)	Revenue (M$)	Profit (M$)
a	0.60	4.74	4.14
b	0.59	4.58	3.99
c	0.51	3.73	3.21
d	0.46	3.02	2.56
e	0.41	2.05	1.64



Energy consumption and emissions

Case	Total House HVAC Energy Consumption (kWh)
a	65002
b	61021
c	61025
d	61044
e	61098

Case	CO2 (1000lb)	SOx (lb)	NOx (lb)
a	17941.9	153.2	1149.3
b	17848.5	152.4	1143.4
c	17647.5	150.7	1130.5
d	17464.0	149.2	1118.7
e	17274.7	147.5	1106.6

Results and Discussion

- Transactive energy systems increases the benefits of the system
- From simulation result: Cost for Case-a is maximum
- Cost reduced at Case-b with Transactive Energy based HVAC Controller
- Significant savings at Case-c with 10% PV power source & 5% Battery storage
- Additional cost savings at Case-d & Case-e with increase of PV by 10% & Storage by 5%

Case-a < Case-b < Case-c < Case-d < Case-e

Conclusion

- Valuation of DER and DES increases cost savings
- With many states, such as NY working towards REV defining TES regulations might be a good idea
- Further research on TES would potentially lead to better optimized markets
- Increase the benefits of stakeholders

Contributions by team members

- Praveen Ashok Kumar
  - Methodology and Software Simulation
  - Results and Discussion
- Rupal Mehta
  - Introduction
  - Literature Review