The Impact of Microgrid on Transmission Network Congestion Management

Jialin(Frank) Liu
Anderson's Lab
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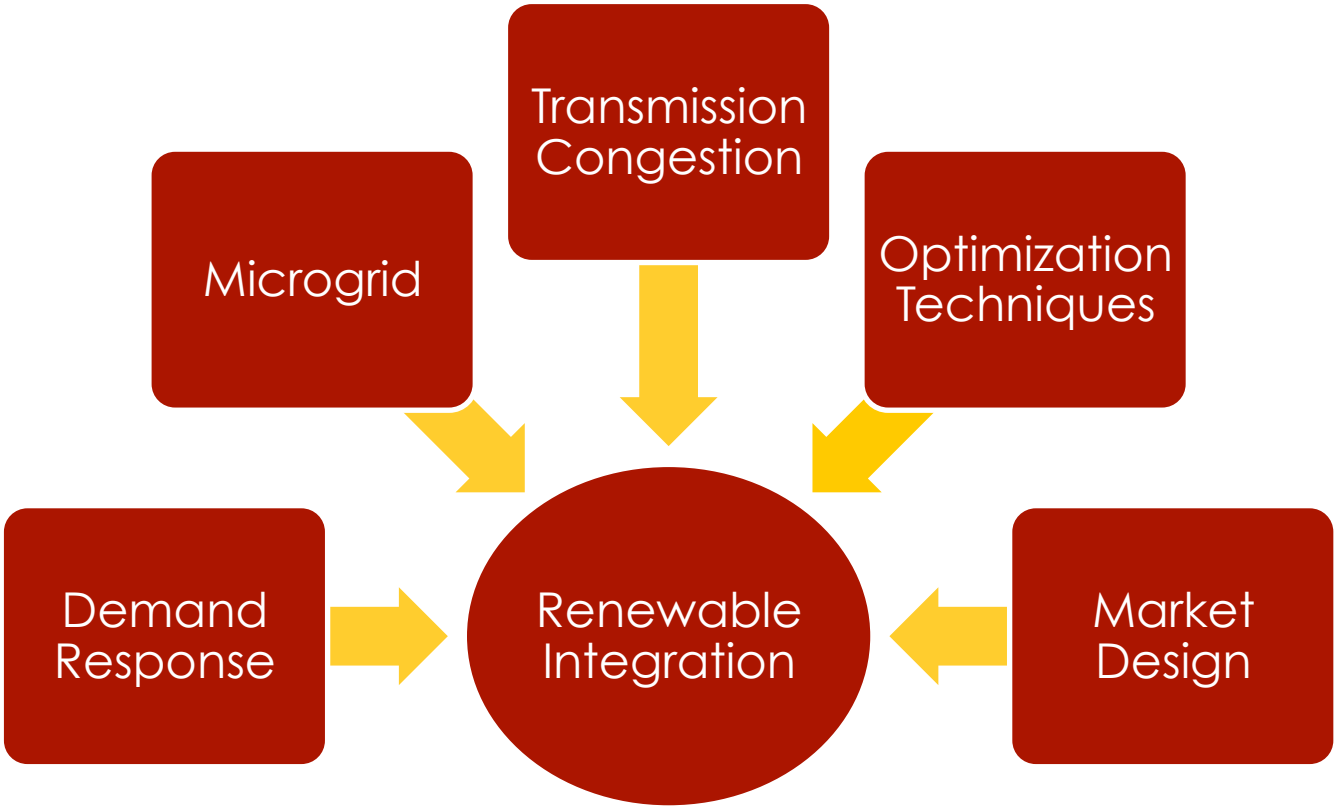
Cornell University

U.S. DEPARTMENT OF ENERGY

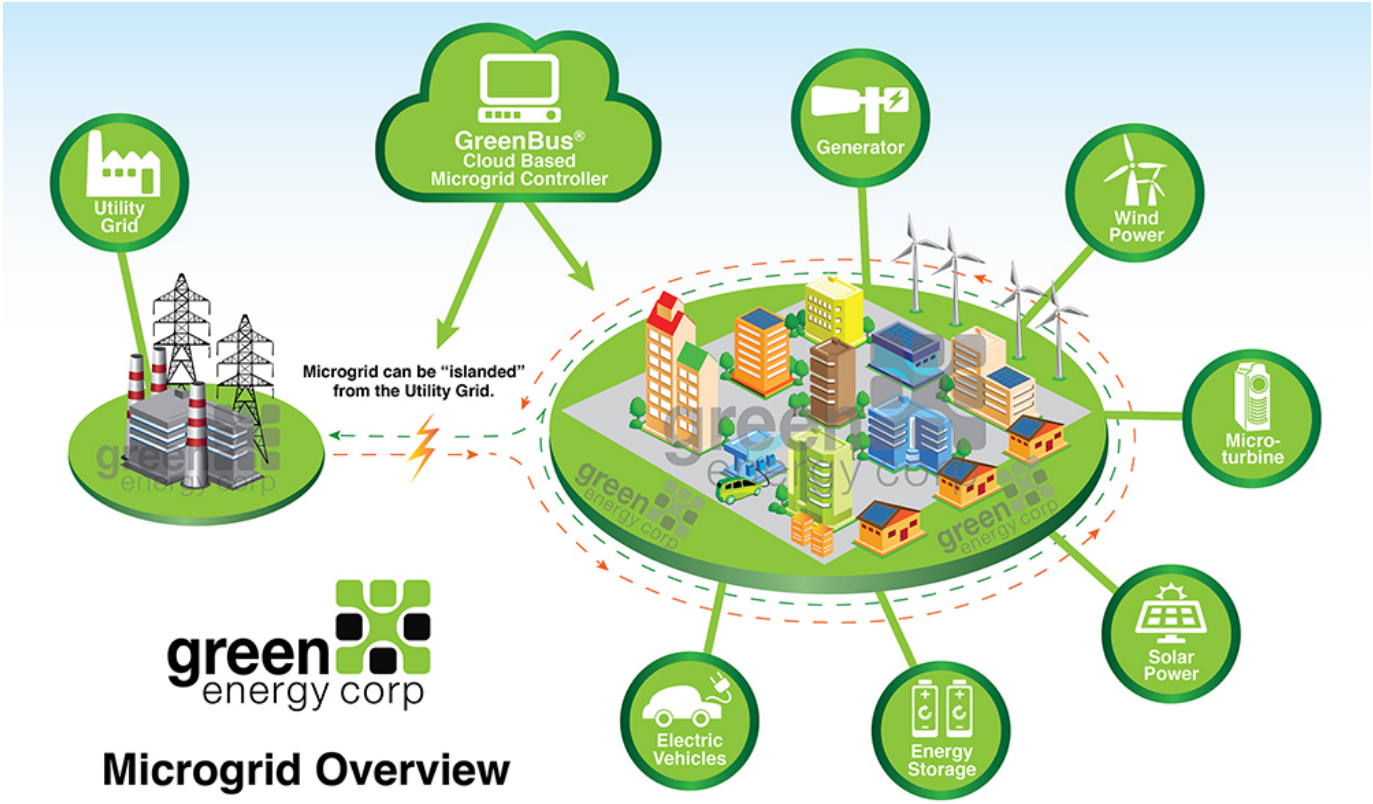
About me

- *PhD student in Electrical and Computer Engineering(ECE) at Cornell University*
- *Minor in Computer Science and Statistics*
- *Bachelor in EE with Power Systems Option from the University of British Columbia*

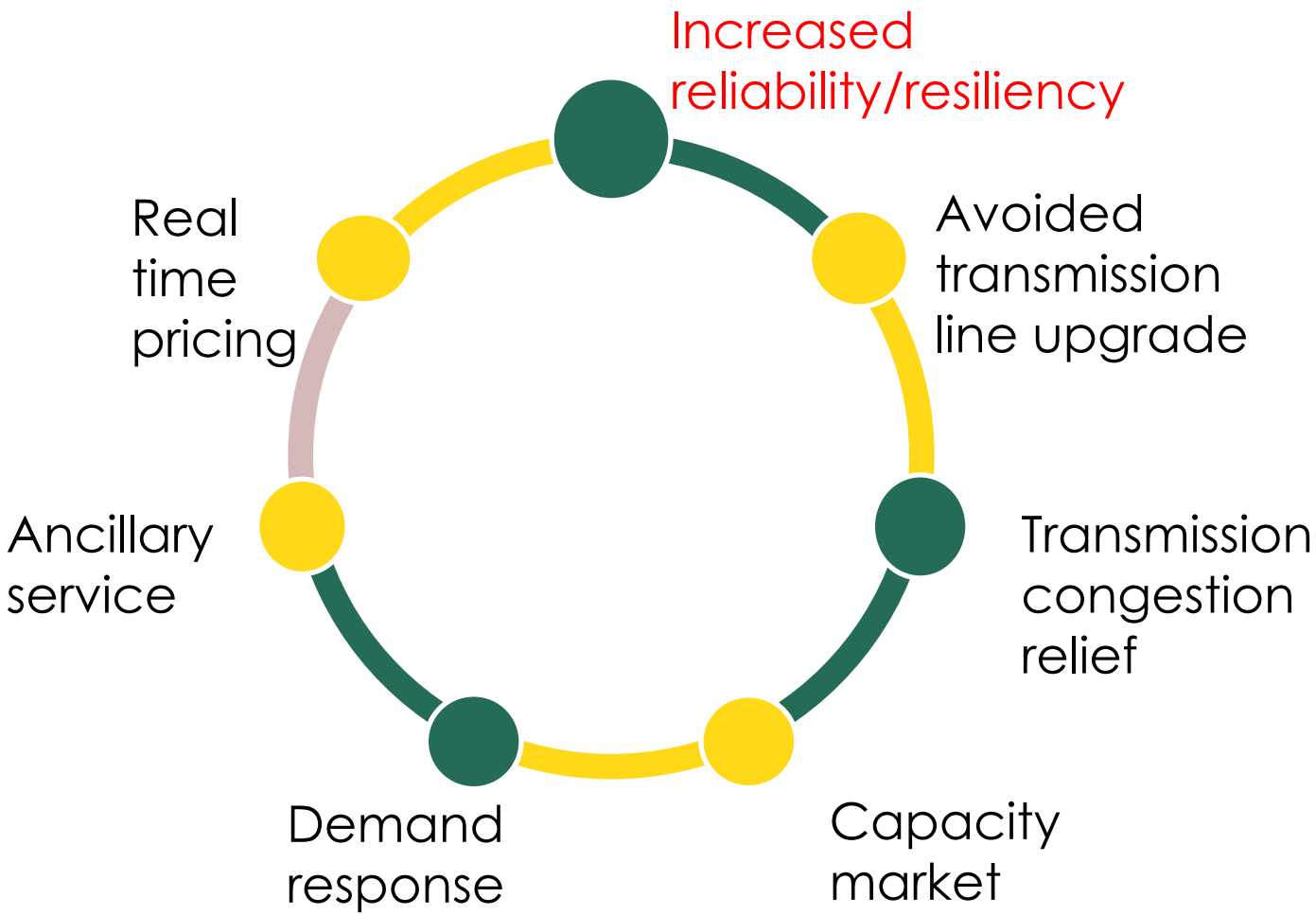
My research


Transmission Congestion
Microgrid
Optimization Techniques
Demand Response
Renewable Integration
Market Design

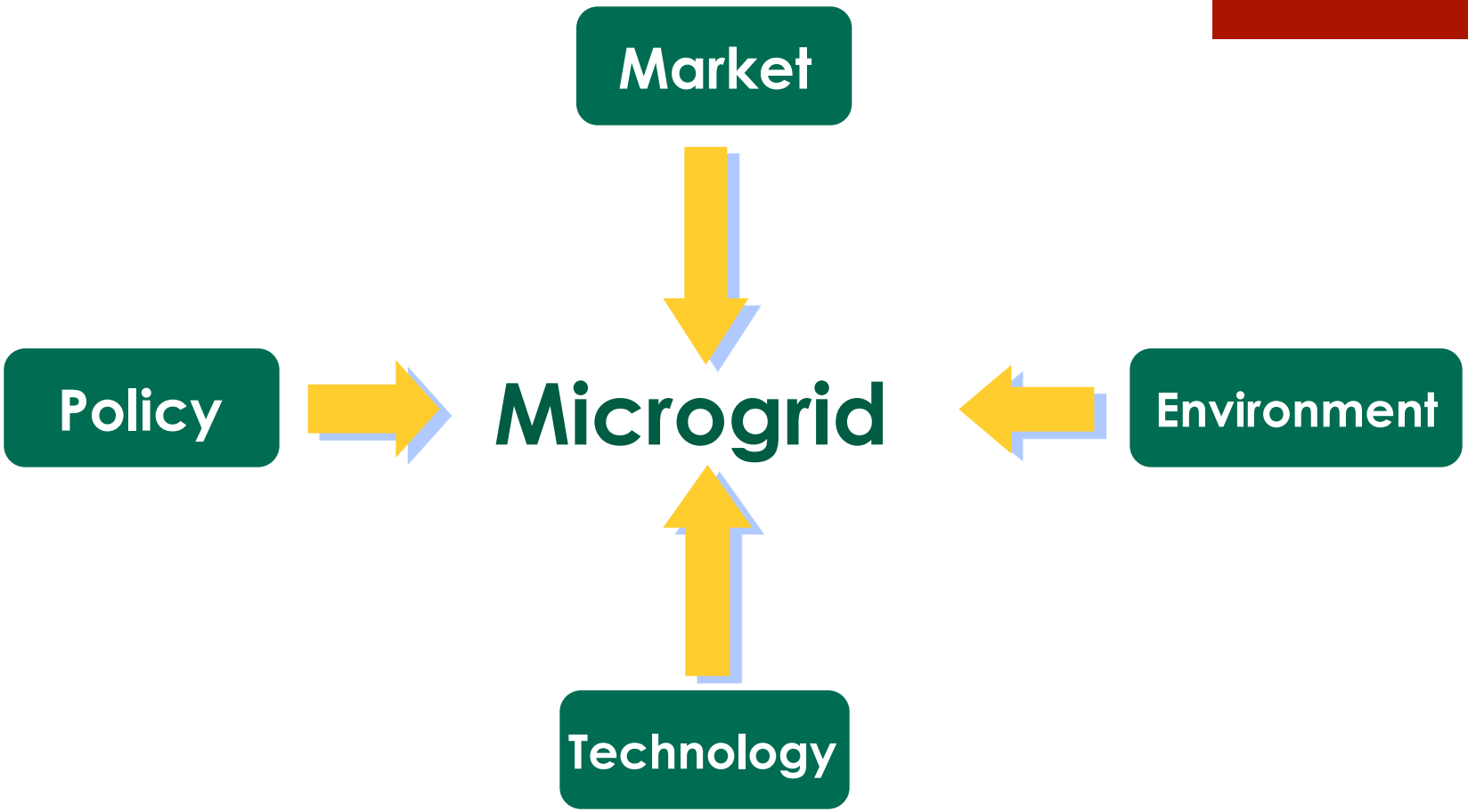
Microgrid


GreenBus®
Cloud Based
Microgrid Controller
Utility Grid
Generator
Wind Power
Micro-turbine
Solar Power
Energy Storage
Electric Vehicles
Microgrid can be "islanded" from the Utility Grid.
green energy corp
Microgrid Overview

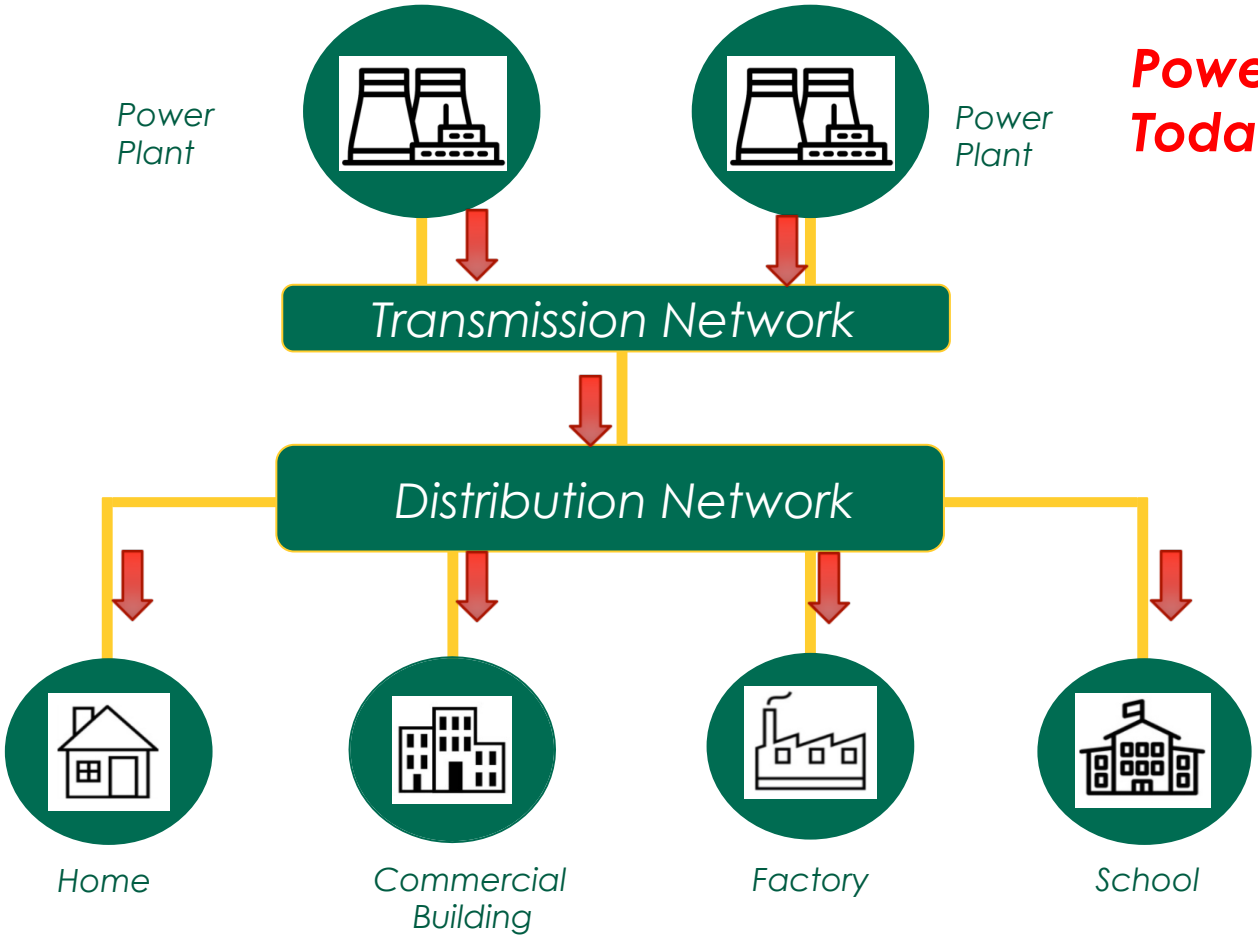
Microgrid Benefits



Driving Forces



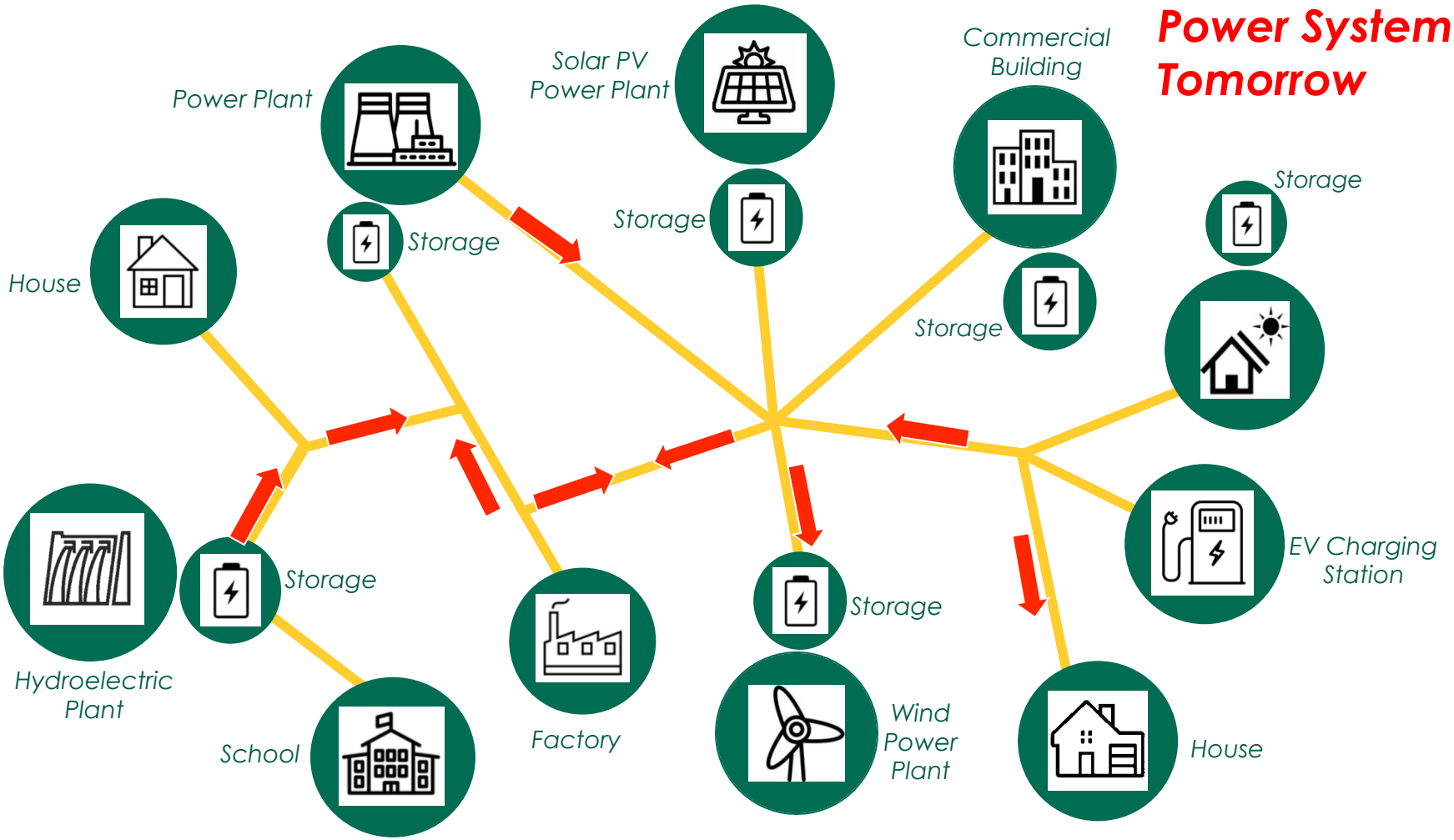
Market&Technology Driver



Power System Today

Market&Technology Driver

Power System Tomorrow



Policy Driver

- President Obama proposed the adoption of a CES in his January 2011 State of the Union address
- A clean energy standard (CES) is one policy option for spurring the deployment of clean energy technology and reducing greenhouse gas emissions from the electric power sector.

Environmental Driver

Objective

- Find the optimal location to place the microgrid in the transmission network
- Create the right microgrid import&export price signals to alleviate transmission congestion

Model: Microgrid

- 3 diesel generators
- One solar farm
- Non-dispatchable and dispatchable load
- 1 storage unit
- Energy import/export capability

Microgrid

- Objective: min(gen cost + battery cost + import cost – export income – dispatchable load utility)
- Subject to: generator constraints

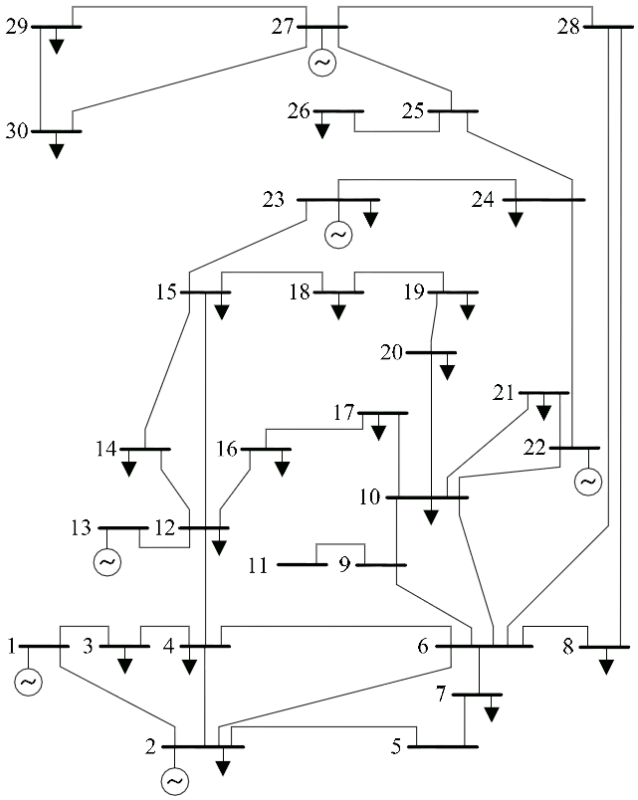
  storage constraints

  dispatchable load constraints

  power balance constraints

Model: Transmission network

- IEEE 30 Bus System
- 30 nodes
- 41 transmission lines
- 6 Generators
- 21 Loads
- A Microgrid connected to a bus



Transmission network

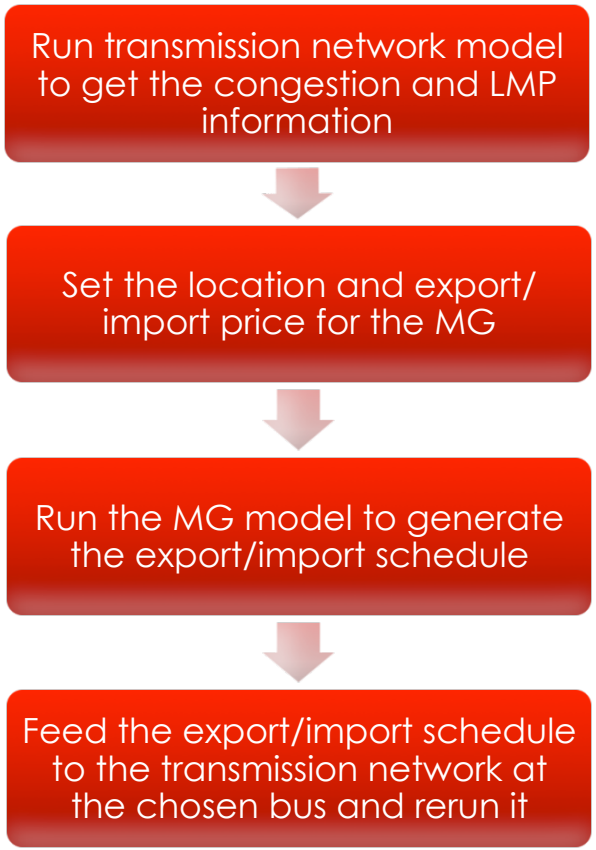
- Objective: min(gen variable cost + gen fixed cost + startup cost)
- Subject to: generator constraints

  power flow constraints

  reserve constraints

  power balance constraints

Methodology-Overview



Methodology-Location

- Run main network and generate all the bus locational marginal price(LMP)
- Place the MG at the highest LMP bus

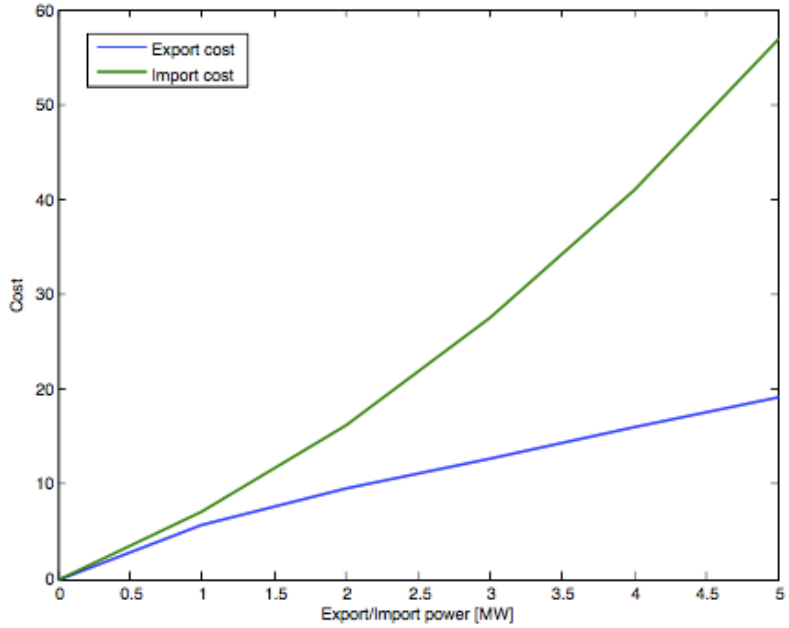
$$LMP=Cost_{energy}+Cost_{congestion}+Cost_{loss}$$

Methodology-Price

- Generate LMPs at different export/import levels at the highest LMP bus
- Set the aggregated cost as the cost function for microgrid import
- Set the export cost function as 80% of the import cost function

Methodology-Price

- The resulting export/import functions are piecewise linear functions



(a) Congested period

Results

- No congestion in the main network: highest LMP bus is bus 8

Case \ t	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
LMP without MG	3.88	3.83	3.82	3.81	3.82	3.82	3.85	3.93	3.97	3.99	4.02	4.01	4.03	4.04	4.03	4.04	4.03	4.00	3.98	3.96	3.95	3.94	3.93	3.91
LMP with MG	3.88	3.84	3.83	3.81	3.83	3.82	3.85	3.93	3.96	3.97	3.99	3.98	4.00	4.01	4.03	4.04	4.03	4.00	3.98	3.96	3.95	3.94	3.93	3.92

Table 1: LMP at bus 8 of the main network with and without MG

- Congestion in the main network: highest LMP bus is bus 8

Case \ t	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
No MG	3.91	3.87	3.86	3.84	3.85	3.85	3.88	3.96	4.04	4.41	5.80	5.40	6.26	6.86	6.56	7.01	6.16	4.69	4.20	3.99	3.98	3.97	3.96	3.94
MG @ bus 6	3.91	3.87	3.86	3.84	3.85	3.85	3.88	3.96	4.07	4.56	6.10	5.75	6.59	7.16	6.63	7.01	6.16	4.69	4.20	3.99	3.98	3.97	3.96	3.95
MG @ bus 17	3.91	3.87	3.86	3.84	3.85	3.85	3.88	3.96	4.05	4.46	5.93	5.54	6.39	6.98	6.59	7.01	6.16	4.69	4.20	3.99	3.98	3.97	3.96	3.95
MG @ bus 8	3.91	3.87	3.86	3.84	3.85	3.85	3.88	3.96	4.00	4.01	4.03	4.01	4.03	4.05	4.05	4.06	4.29	4.02	4.02	3.99	4.00	4.08	3.96	3.95

Table 2: LMP at bus 8 of the main network without MG and with MG at different buses

Results

- Monte Carlo simulation on 31 solar scenarios

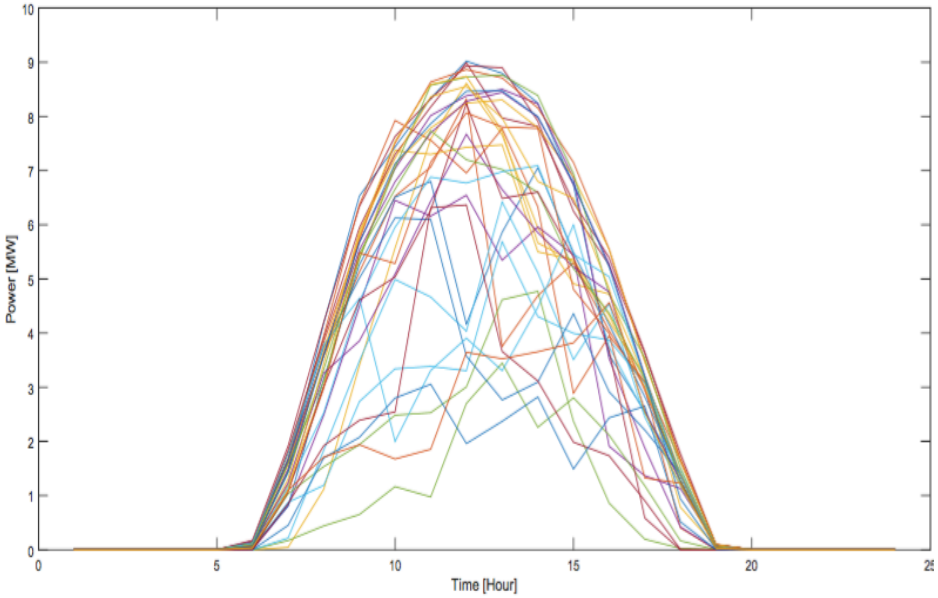


Figure 5: Solar Generation Scenarios.

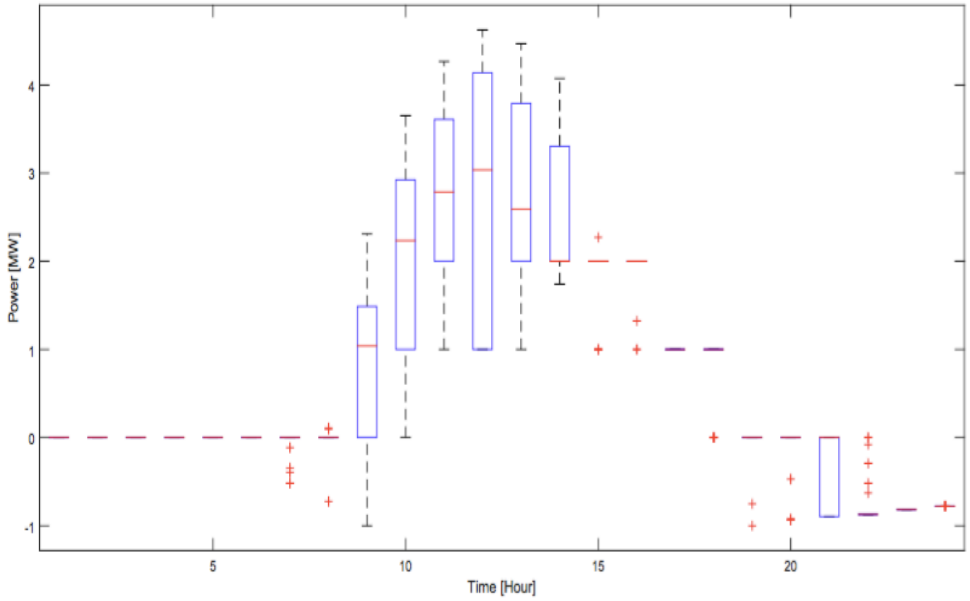


Figure 7: Net Export Distribution.

Results

- Compare PWL pricing scheme with two other schemes

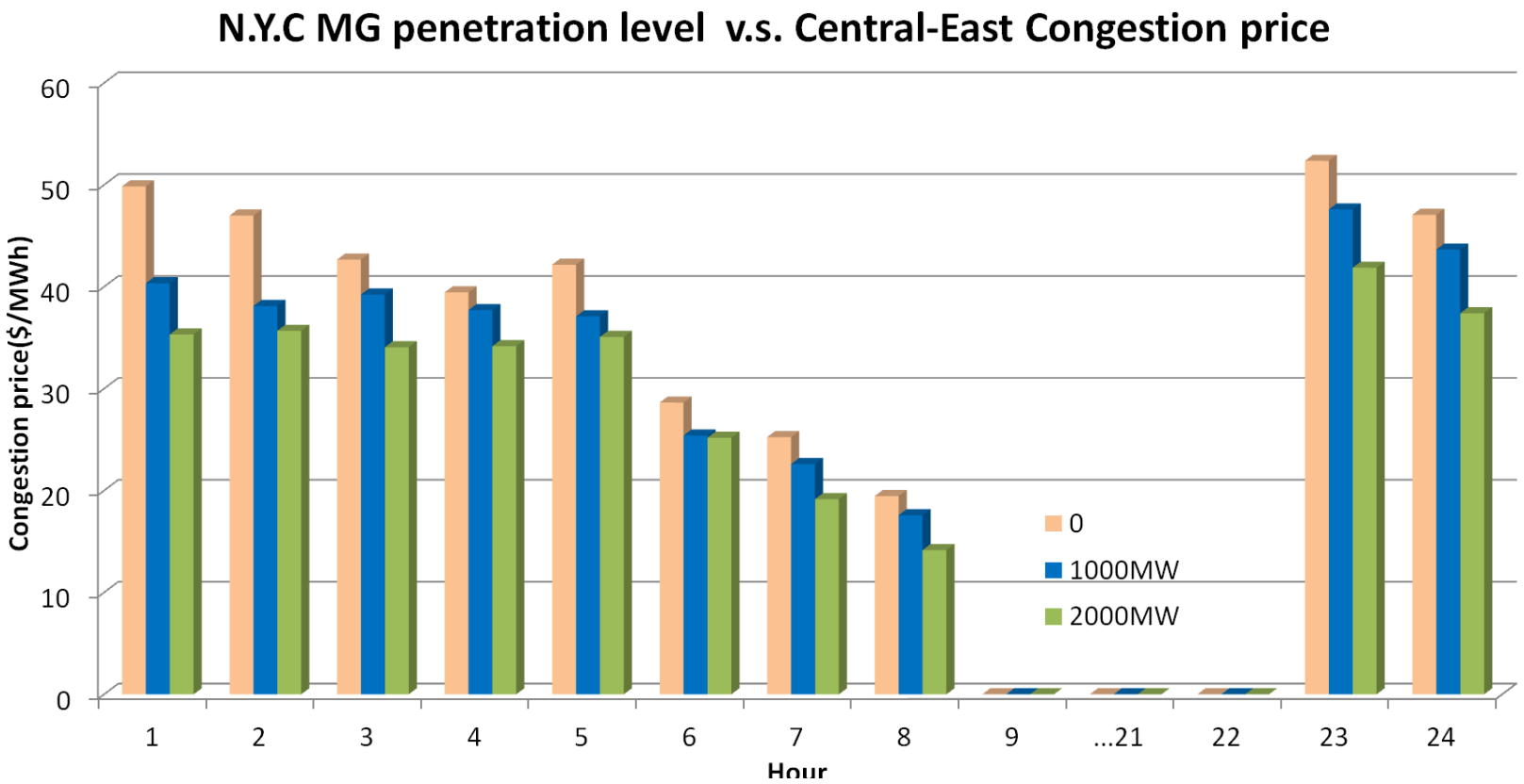
1. FLMP: use the fixed LMP in the case of congestion which is the first row in Tab.(2) as the import price and 80% of that as the export price.

2. HLMP: use the maximum LMP value in the same row of LMP for all the periods as the import price and 80% of that as the export price.

t	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
PWL	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
FLMP	0	0	0	0	0	0	0	8	6	0	0	9	0	0	0	0	6	8	22	0	0	0	0	0
HLMP	0	0	0	0	0	0	0	0	0	0	1	0	4	4	4	23	31	0	0	0	0	0	0	0

Table 3: Number of congestions on line from bus 6 to bus 8

Transmission Relief



Conclusion

- The interaction between the microgrid and the transmission system has very intricate behavior
- Placing the microgrid at the right bus using the right pricing scheme could help with transmission congestion.
- It is worthwhile to study other aspects of this interaction to bring out more benefits from the microgrid

Thanks for your attention!