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Tactical Mobile Microgrid Project Year 1 Accomplishments

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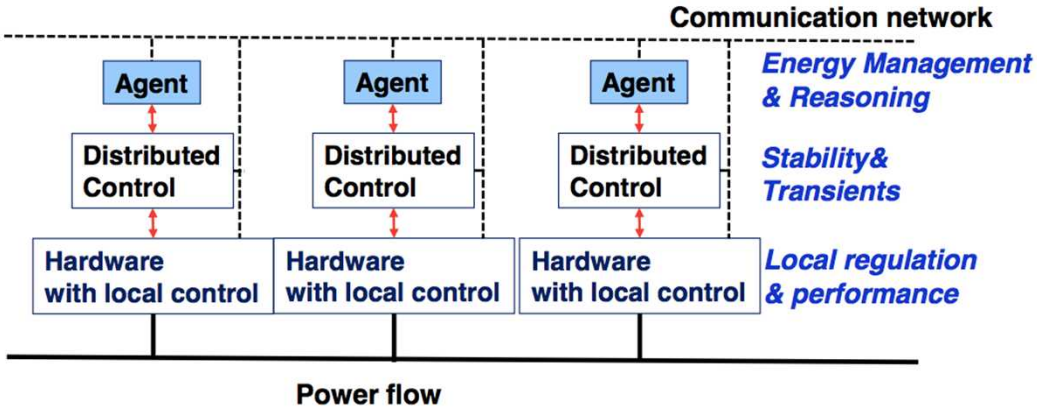
SNL Project Role

- **Provide advanced controls to minimize diesel fuel usage and operation time with flexible tactical microgrid configurations**
- **Deploying an innovative multi-layer distributed control architecture**



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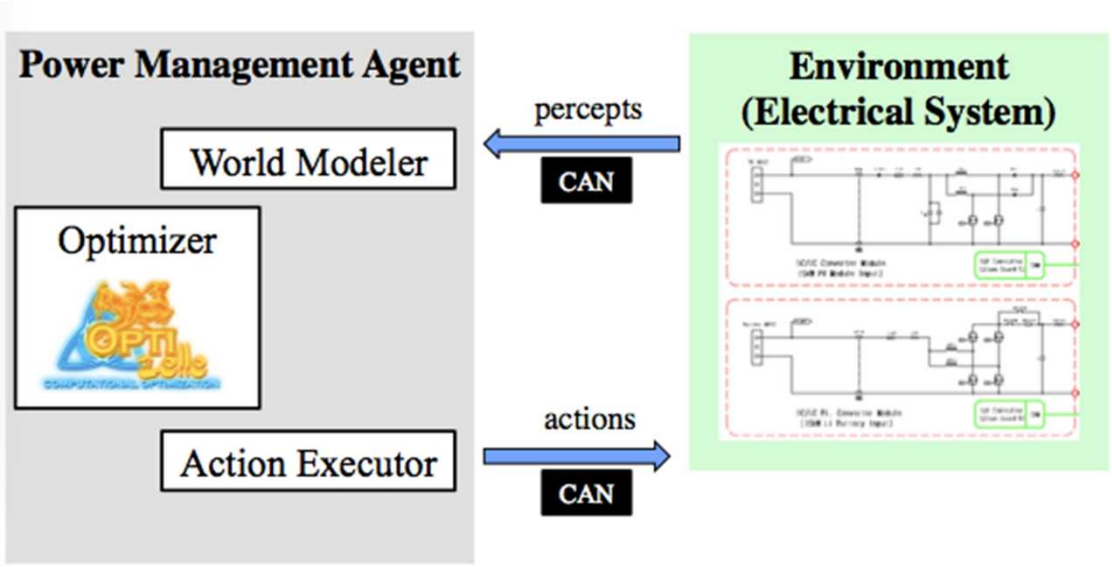
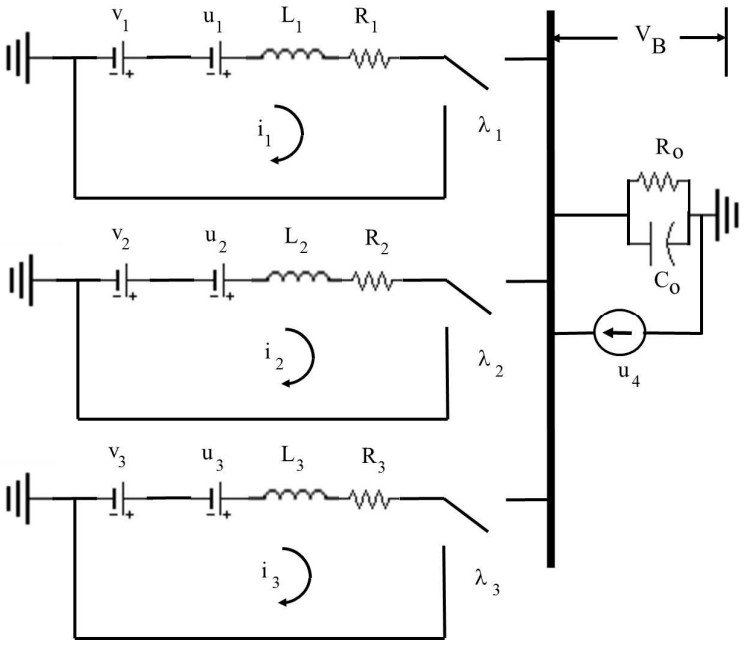
Multi-Agent System Design

- **Power Management Agent interprets energy system measurements and sends control commands**
- **Agent paired with Microgrid Module and coordinates power flow with peer Agents**



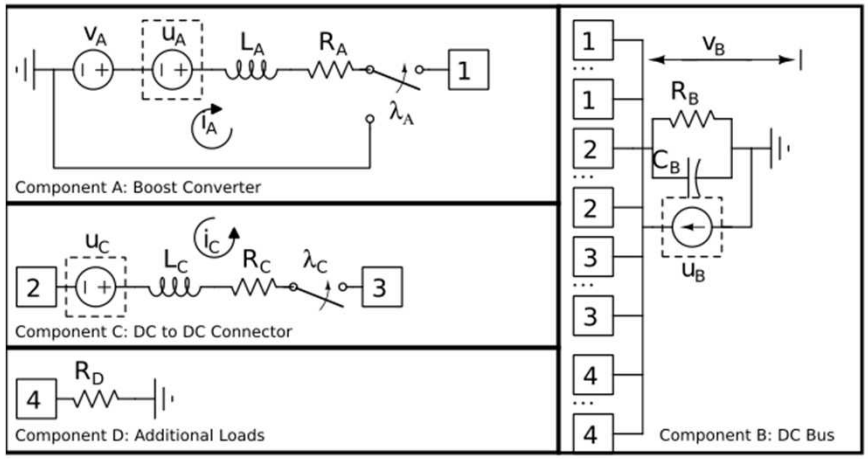
Hamiltonian Control Design

- Satisfies power stability criteria across multiple microgrids
- Reduced order models developed to match tactical microgrid module specifications
- Problem formulation with circuit equations provide storage control actions



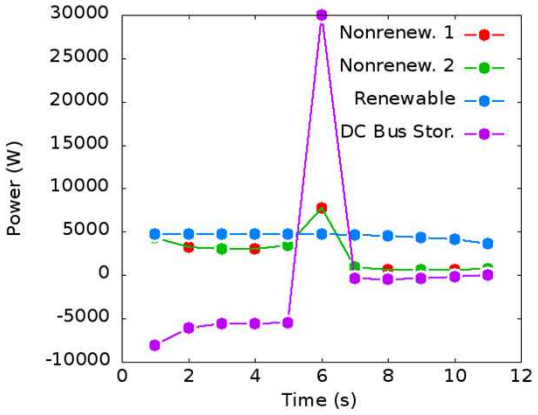
Optimization Engine

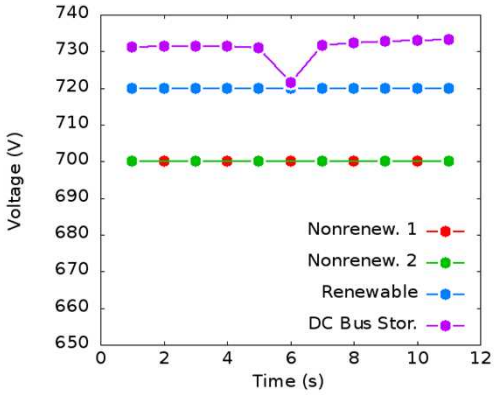
- Coordinates operation of multiple generators, loads, buses, and storage devices
- Software agents request optimization solutions using measured and possible system states
- Supports multiple microgrid configurations



Preliminary Control Results

- Results based on tactical microgrid module setup
- Optimization accounts for load profile by storing energy then meeting demand
- Cost functions allow selection of appropriate generation
- Cost functions support minimizing fuel usage





Estimating Diesel Fuel Consumption

- **Developed spreadsheet to calculate fuel consumption**
- **Supports control strategy evaluation for various load profiles**

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Time Step	1	Mins		NOTE: GENS MUST BE SAME SIZE												
2																Fuel Consumption	
3	Module 1			Module 2			Module 3					Module # / Gen #		0	10	25	50
4	Gen 1 Size	20	kW	Gen 1 Size	20	kW	Gen 1 Size	20	kW			1/1	20	0.45	0.513708552	0.6	0.9
5	Gen 2 Size	20	kW	Gen 2 Size	20	kW	Gen 2 Size	20	kW			1/2	20	0.45	0.513708552	0.6	0.9
6	Energy Storage kW	15	kW	Energy Storage kW	15	kW	Energy Storage kW	15	kW			2/1	20	0.45	0.513708552	0.6	0.9
7	Energy Storage kWh	15	kWh	Energy Storage kWh	15	kWh	Energy Storage kWh	15	kWh			2/2	20	0.45	0.513708552	0.6	0.9
8	Initial SOC	51	%	Initial SOC	51	%	Initial SOC	51	%			3/1	20	0.45	0.513708552	0.6	0.9
9	SOC Engagement	50	%	SOC Engagement	50	%	SOC Engagement	50	%			3/2	20	0.45	0.513708552	0.6	0.9
10	Upper SOC	90	%	Upper SOC	90	%	Upper SOC	90	%								
11	Lower SOC	10	%	Lower SOC	10	%	Lower SOC	10	%			Simulatin Time	4.00	days			
12	Round-Trip Eff Charge	15	%	Round-Trip Eff Charge	15	%	Round-Trip Eff Charge	15	%			Fuel Used	128.801	gallons			
13	Round-Trip Eff Discharge	15	%	Round-Trip Eff Discharge	15	%	Round-Trip Eff Discharge	15	%			ESS 1 Cycles	9.37				
14	Charge Rate	15	kW/min	Charge Rate	15	kW/min	Charge Rate	15	kW/min			ESS 2 Cycles	9.37				
15	PV Array Size	5	kW	PV Array Size	0	kW	PV Array Size	2	kW			ESS 3 Cycles	9.37				
16																	
17	Good Design																
18																	
19		Peak	50000.00			Peak	50000.00										
20		Min	3257.51			Min	0.00										
21		Average	13267.82			Average	6627.60										
22	Time Step	Load (W)	PV 1 (W)	PV 2 (W)	PV 3 (W)	Total Load	ESS1 SOC	ESS2 SOC	ESS3 SOC	ESS1 Avail	ESS2 Avail	ESS3 Avail	Discharge ESS1 kW	Discharge ESS2 kW	Discharge ESS3 kW	ESS Only	TIER
23	1	7383.20	0	0	0	7383.20	51.00%	51.00%	51.00%	1	1	1	15000.00	15000.00	15000.00	1	
24	2	9432.51	0	0	0	9432.51	50.69%	50.69%	50.69%	1	1	1	15000.00	15000.00	15000.00	1	
25	3	7387.69	0	0	0	7387.69	50.28%	50.28%	50.28%	1	1	1	15000.00	15000.00	15000.00	1	
26	4	7383.25	0	0	0	7383.25	49.97%	49.97%	49.97%	1	1	1	15000.00	15000.00	15000.00	1	
27	5	7371.30	0	0	0	7371.30	49.65%	49.65%	49.65%	1	1	1	15000.00	15000.00	15000.00	1	
28	6	9136.91	0	0	0	9136.91	49.34%	49.34%	49.34%	1	1	1	15000.00	15000.00	15000.00	1	
29	7	7402.23	0	0	0	7402.23	48.95%	48.95%	48.95%	1	1	1	15000.00	15000.00	15000.00	1	
30	8	7406.14	0	0	0	7406.14	48.64%	48.64%	48.64%	1	1	1	15000.00	15000.00	15000.00	1	
31	9	9141.86	0	0	0	9141.86	48.32%	48.32%	48.32%	1	1	1	15000.00	15000.00	15000.00	1	
32	10	6995.12	0	0	0	6995.12	47.93%	47.93%	47.93%	1	1	1	15000.00	15000.00	15000.00	1	
33	11	6993.63	0	0	0	6993.63	47.63%	47.63%	47.63%	1	1	1	15000.00	15000.00	15000.00	1	
34	12	9149.80	0	0	0	9149.80	47.34%	47.34%	47.34%	1	1	1	15000.00	15000.00	15000.00	1	
35	13	8724.42	0	0	0	8724.42	46.95%	46.95%	46.95%	1	1	1	15000.00	15000.00	15000.00	1	
36	14	7912.12	0	0	0	7912.12	46.57%	46.57%	46.57%	1	1	1	15000.00	15000.00	15000.00	1	
37	15	7909.19	0	0	0	7909.19	46.24%	46.24%	46.24%	1	1	1	15000.00	15000.00	15000.00	1	
38	16	9144.14	0	0	0	9144.14	45.90%	45.90%	45.90%	1	1	1	15000.00	15000.00	15000.00	1	
39	17	7398.98	0	0	0	7398.98	45.51%	45.51%	45.51%	1	1	1	15000.00	15000.00	15000.00	1	
40	18	7406.11	0	0	0	7406.11	45.20%	45.20%	45.20%	1	1	1	15000.00	15000.00	15000.00	1	

Summary | Analysis | Tactical Microgrid Analysis | Generator Schedule | Diesel Gen | NG Gen | PV

Preliminary Models: MATLAB Simulink

- MatLab Simulink model development started to characterize tactical mobile microgrids
- Models requires further definition and refinement at microgrid interconnections
- Models will be translated to real time simulation environments
- Multi-agent system controls will receive measurements and send controls to simulated models

Next Steps

- Validate reduced order model congruence with detailed system representation
- Improve the multi-agent system and optimization control implementation specific to demonstration scenarios
- Proceed with Software Licensing/Sharing to Luxco and KIER for multi-agent system and Optizelle specializations

Remaining Major Tasks

2nd Year

- Develop a set of Matlab Simulink models of multiple microgrids
- Integrate software agent with control and optimization algorithms
- Design and implementation of remote diagnosis capability
- Test and refinement of control strategies

3rd Year

- Support for development of hardware architecture
- Support for integrating control strategies into hardware architecture
- Participate in microgrid demonstration