Dynamics-incorporated Hybrid Symbolic-Numeric Modeling for Stability Constrained Production Cost Simulation

Market Simulator for CURENT Large-scale Testbed

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Dispatch Modeling Challenges

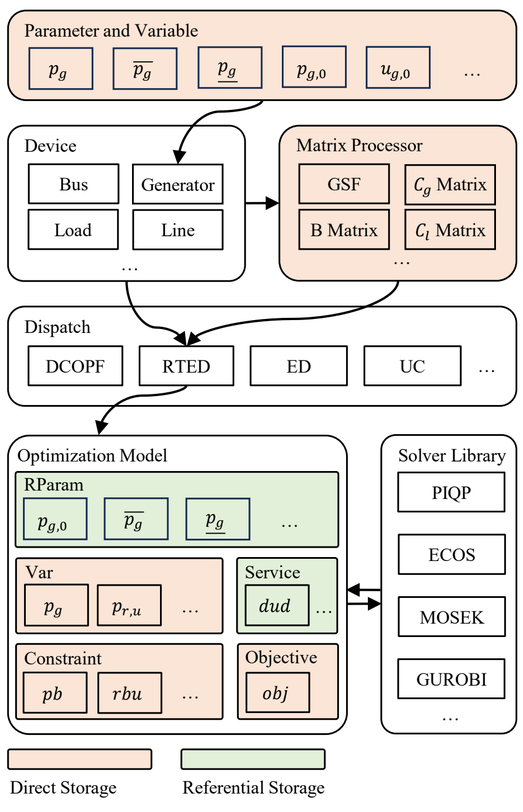
- Incorporate new dispatchable devices and elements
- Integrate dynamics into dispatch to ensure dynamic stability
- Modeling gaps between the device level and the system dispatch level

Contributions

- Bridge the modeling gap
- Streamline the dispatch modeling via modular design
- Enable interoperation with dynamics

Design Philosophy

Dispatch modeling scheme



Input formats

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	uid	idx	u	name	Vn	vmax	vmin	v0	a0	xcoord	ycoord	area	zone	owner
2	0	1	1	BUS1	345	1.1	0.9	1.03145	-0.214096	0	0	AREA1	ZONE1	
3	1	2	1	BUS2	345	1.1	0.9	1.00247	-0.250216	0	0	AREA1	ZONE1	
4	2	3	1	LOAD3	345	1.1	0.9	0.95348	-0.334253	0	0	AREA1	ZONE1	
5	3	4	1	LOAD4	345	1.1	0.9	0.93103	-0.336252	0	0	AREA1	ZONE1	
6	4	5	1	BUS5	345	1.1	0.9	0.91744	-0.304876	0	0	AREA1	ZONE1	
7	5	6	1	BUS6	345	1.1	0.9	0.91858	-0.291919	0	0	AREA1	ZONE1	
8	6	7	1	LOAD7	345	1.1	0.9	0.86255	-0.325226	0	0	AREA1	ZONE1	
9	7	8	1	LOAD8	345	1.1	0.9	0.87995	-0.332171	0	0	AREA1	ZONE1	
10	8	9	1	BUS9	345	1.1	0.9	0.9788	-0.244875	0	0	AREA1	ZONE1	
11	9	10	1	BUS10	345	1.1	0.9	0.95616	-0.256497	0	0	AREA1	ZONE1	
12	10	11	1	BUS11	345	1.1	0.9	0.94295	-0.270254	0	0	AREA1	ZONE1	
13	11	12	1	LOAD12	138	1.1	0.9	0.94491	-0.300265	0	0	AREA1	ZONE1	
14	12	13	1	BUS13	345	1.1	0.9	0.95234	-0.272154	0	0	AREA1	ZONE1	
15	13	14	1	BUS14	345	1.1	0.9	0.94651	-0.302902	0	0	AREA1	ZONE1	
16	14	15	1	LOAD15	345	1.1	0.9	0.95647	-0.314027	0	0	AREA1	ZONE1	
17	15	16	1	LOAD16	345	1.1	0.9	0.97673	-0.287794	0	0	AREA1	ZONE1	
18	16	17	1	BUS17	345	1.1	0.9	0.97495	-0.307646	0	0	AREA1	ZONE1	
19	17	18	1	LOAD18	345	1.1	0.9	0.9652	-0.326169	0	0	AREA1	ZONE1	
20	18	19	1	BUS19	345	1.1	0.9	1.02958	-0.203839	0	0	AREA1	ZONE1	
21	19	20	1	LOAD20	138	1.1	0.9	0.97981	-0.229705	0	0	AREA1	ZONE1	

Summary | Bus | PV | Slack | Line | Shunt | PQ | Area | Region | GCost | DCost | NSRCost | SRCost | SFRCost | SR | NSR | SFR | EDTSlot | UCTSlot

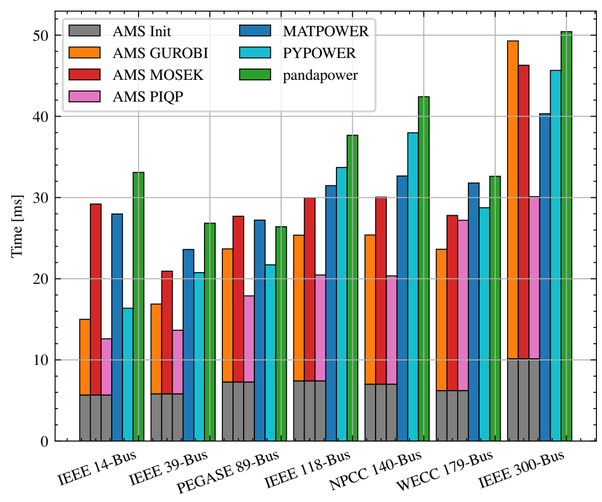
Power Flow Data | Economic Data | Reserve Data | Multi-period Data

Case Study

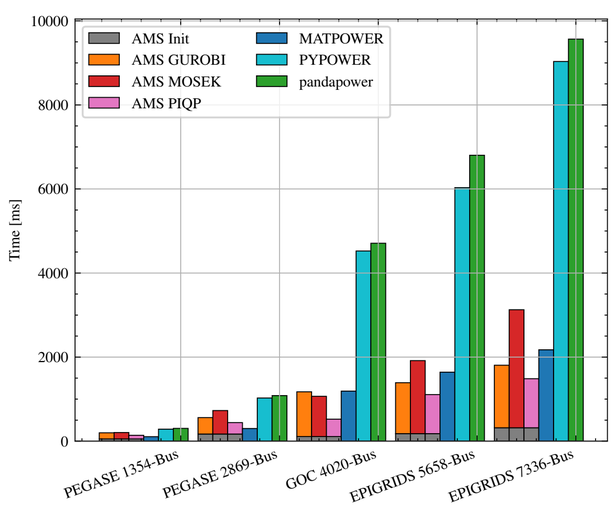
Benchmark of DCOPF costs

Cost [$]	AMS	MATPOWER	pandapower
IEEE 14-Bus	7,642.59	7,642.59	7,642.59
IEEE 39-Bus	41,263.94	41,263.94	41,263.94
PEGASE 89-Bus	5,733.37	5,733.37	5,733.37
IEEE 118-Bus	125,947.88	125,947.88	125,947.88
NPCC 140-Bus	705,667.89	705,667.89	705,667.89
WECC 179-Bus	348,228.36	348,228.36	348,228.36
IEEE 300-Bus	706,292.32	706,292.32	706,292.32
PEGASE 1354-Bus	1,173,590.63	1,173,590.63	1,173,590.63
PEGASE 2869-Bus	2,338,915.61	2,338,915.61	2,338,915.61
GOC 4020-Bus	793,634.11	793,634.11	793,634.11
EPIGRIDS 5658-Bus	1,195,466.12	1,195,466.12	1,195,466.12
EPIGRIDS 7336-Bus	1,855,870.94	1,855,870.94	1,855,870.94

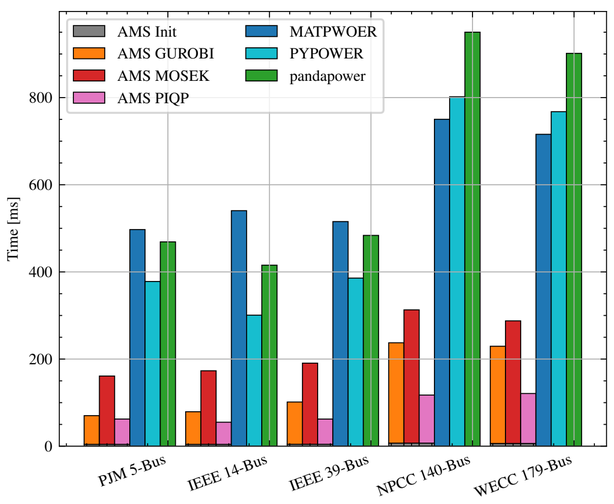
Computation time of OPF on small to medium scale cases



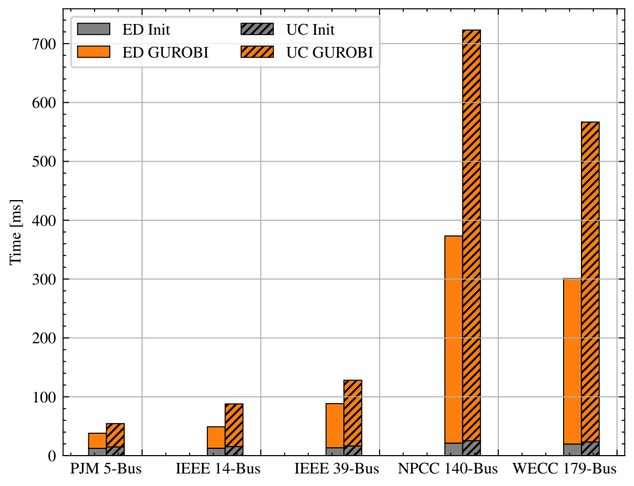
Computation time of OPF on large scale cases



Computation time of 24-hour load level scanning using OPF



Computation time of multi-period dispatch



Conclusions

- A modularized dispatch modeling framework
- Framework features: ***extensible*** dispatch formulation, ***scalable*** performance, ***compatible*** data structure, ***interoperable*** operation with dynamic simulators.
- Enable development efforts for dispatch modeling and dispatch-dynamic co-simulation.
- Empower CURENT LTB with dispatch functionality

Future Work

- Multi timescale dispatch coordination for digital twin prototype
- Dispatch algorithms that effectively incorporate dynamics constraints
- Virtual energy market to for new market mechanisms