



Report on:

ERCOT PNNL Contract 401882: *Start Date 3/19/2018*

Development of an Integrated Transmission and Distribution Test System to Evaluate Transactive Energy Systems

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PNNL/ISU Web Conference, 11 January 2019

ERCOT Contract: Presentation Outline

- Original Task/Milestone Schedule: M1-M3
- Updated Task/Milestone Schedule: M1-M3
- Summary of Work Done for Milestone M3.2
- Summary of Work in Progress for Milestone M3.2
- Test-case input/output data verifying that AMES V5.0 correctly refreshes initial DAM/RTM conditions in multiple-day runs

Original Task & Milestone Schedule

Milestone	Date Due	Original Description
M1	May 31, 2018	5-zone model of the old ERCOT system, posted to a web repository.
M2	Sep 30, 2018	Nodal model of the new ERCOT system, posted to a web repository.
M3	Sep 30, 2018	Submitted conference or journal paper on this work.

Updated Task & Milestone Schedule

Milestone	Date Due	Date Delivered	Fuller Descriptions of Actual Work
M1* DONE	May 31, 2018	June 5, 2018	Development of 8-Bus ERCOT model (with nodal locational marginal pricing); grid/load/gen data posted at PNNL repository
M2.1 DONE	Sept 30, 2018	August 1, 2018	Basic 8-Bus ERCOT Test System, implemented via AMES V3.1, posted at https://github.com/ITDProject/ERCOTTestSystem
M2.2 DONE	Sept 30, 2018	August 24, 2018	8-Bus ERCOT Test System (with wind power), implemented via AMES V3.2, posted at https://github.com/ITDProject/ERCOTTestSystem
M3.1 DONE	Sept 30, 2018	August 31, 2018	200-Bus ERCOT Test System (with wind power), implemented via AMES V3.2, posted at https://github.com/ITDProject/ERCOTTestSystem/tree/master/ERCOT_Test_Systems/The_200Bus_ERCOT_Test_System
M3.2**	Feb 28, 2019		200-Bus ERCOT Test System (with wind power), implemented via AMES V5.0, to be posted at PNNL/ISU repositories.
M3.3**	Feb 28, 2019		Paper to be submitted that focuses on the development of the ERCOT Test Systems

- * **M1 Modification (Ok'd by PNNL):** For M1 we have skipped the modeling of the old (zonal) ERCOT system and instead directly worked to develop an 8-bus model of the new (nodal) ERCOT system.
- ** **M3 Modification:** Contract extension through Feb 28, 2019 received from PNNL on Dec 21, 2018, for completion of task M3

Summary of Work Done for Milestone M3.2

❑ Extension of AMES V5.0 Capabilities for Milestone M3.2

- [DONE] Coding for Daily DAM SCUC optimization
- [DONE] Coding for RTM SCED optimization every M minutes (M user specified).
- [DONE] Coding for FNCS integration to enable network co-simulation.
- [DONE] Detailed documentation for analytical DAM SCUC/SCED optimization in AMES V5.0
- [DONE] Basic documentation for AMES V5.0, including a detailed list for all parameters/flags and initial state variables that need user configuration.

Summary of Work Done for Milestone M3.2 ... Continued

■ [DONE]

— Modified 'PSST' Code

- To ensure correct refreshing of initial DAM/RTM conditions for multiple-day runs.
- To report DAM LMPs and GenCo Commitments back to the user.
- To read 'startup' and 'shutdown' cost components from AMES
- To produce output messages related to solver, e.g. status of the solver, termination condition of the solver
- To include the parameter 'Maximum Time Limit' – to allow the solver to terminate after the prescribed time has elapsed

— Verification Tests Done

- Verified 'DAM SCUC' outcomes for their correctness for simple test cases
- Verified 'RTM SCED' outcomes for their correctness for simple test cases with RTM running every five minutes (i.e., $M=5$)
- Verified that AMES V5.0 runs for multiple days
- Verified that all the cost components from AMES are read correctly into the SCUC formulation

Summary of Work in Progress for Milestone M3.2

- **[IN PROGRESS] Additional Verification Checks for AMES V5.0 Code**
 - Additional DAM/RTM verification test cases are being formulated and conducted.
 - *Example:* Formulation of test cases with varied generator production cost coefficients and minimum generating capacity that permit validation of production cost component modeling for the SCUC optimization
 - Need to ensure outcomes are reported properly back to the user. Additional data that need to be written to '.out' file are: RTM LMPs, RTM GenCo commitment data, DAM/RTM power flow data, LMP true costs, and generator profit/propensity data.
 - Detailed verification of PSST code for validating SCUC optimization formulation, including both objective function and constraints.
- **[IN PROGRESS] Further Cleaning Up of AMES V5.0 Code**
 - Current code includes unused functions that need to be removed.

Verification Test Case 1: Input Data

➤ **8BusTestCase1:** A test case to verify correct refreshing of initial DAM/RTM conditions

Some of the *input data* given in 8BusTestCase1.dat are presented below.



8BusTestCase1.dat

#GenDataStart

// Name	ID	atBus	FCost	a	b	capL	capU	InitMoney
GenCo1	1	1	0.0000	10.0000	0.0050	100	1000	1000000.0000
GenCo2	2	2	0.0000	11.0000	0.0060	90	1000	1000000.0000
GenCo3	3	3	0.0000	12.0000	0.0070	80	1000	1000000.0000
GenCo4	4	4	50000	13.0000	0.0080	100	1000	1000000.0000
GenCo5	5	5	50000	14.0000	0.0090	100	1000	1000000.0000
GenCo6	6	6	50000	20.0000	0.0091	100	1000	1000000.0000
GenCo7	7	7	50000	20.0000	0.0092	100	1000	1000000.0000
GenCo8	8	8	50000	20.0000	0.0093	100	1000	1000000.0000

#GenDataEnd

#ScucInputDataStart

// Name	PowerT0	UnitOnT0	MinUpTime	MinDownTime	NominalRampUp	NominalRampDown	StartupRampLim	ShutdownRampLim	Schedule	Schedule2
GenCo1	1000.0000	1	0	0	0	0	0	0	1	1
GenCo2	1000.0000	1	0	0	0	0	0	0	1	1
GenCo3	1000.0000	1	0	0	0	0	0	0	1	1
GenCo4	1000.0000	1	0	0	0	0	0	0	1	1
GenCo5	1000.0000	1	0	0	0	0	0	0	1	1
GenCo6	1000.0000	1	0	0	0	0	0	0	1	1
GenCo7	1000.0000	1	0	0	0	0	0	0	1	1
GenCo8	1000.0000	1	0	0	0	0	0	0	1	1

#ScucInputDataEnd

Verification Test Case 1: Input Data ... Continued

➤ **8BusTestCase1:** A test case to verify correct refreshing of initial DAM/RTM conditions

Some of the *input data* given in 8BusTestCase1.dat are presented below.



8BusTestCase1.dat

#LSEDataFixedDemandStart											
// Name	ID	atBus	H0	H1	H2	H3	H4	H5	H6	H7	
LSE1	1	1	1200	2200	3200	4200	200	200	200	200	
LSE2	2	2	200	200	200	200	200	200	200	200	
LSE3	3	3	200	200	200	200	200	200	200	200	
LSE4	4	4	200	200	200	200	200	200	200	200	
LSE5	5	5	200	200	200	200	200	200	200	200	
LSE6	6	6	200	200	200	200	200	200	200	200	
LSE7	7	7	200	200	200	200	200	200	200	200	
LSE8	8	8	200	200	200	200	200	200	200	200	
// Name	ID	atBus	H8	H9	H10	H11	H12	H13	H14	H15	
LSE1	1	1	200	200	200	200	200	200	200	200	
LSE2	2	2	200	200	200	200	200	200	200	200	
LSE3	3	3	200	200	200	200	200	200	200	200	
LSE4	4	4	200	200	200	200	200	200	200	200	
LSE5	5	5	200	200	200	200	200	200	200	200	
LSE6	6	6	200	200	200	200	200	200	200	200	
LSE7	7	7	200	200	200	200	200	200	200	200	
LSE8	8	8	200	200	200	200	200	200	200	200	
// Name	ID	atBus	H16	H17	H18	H19	H20	H21	H22	H23	
LSE1	1	1	200	200	200	200	200	200	200	200	
LSE2	2	2	200	200	200	200	200	200	200	200	
LSE3	3	3	200	200	200	200	200	200	200	200	
LSE4	4	4	200	200	200	200	200	200	200	200	
LSE5	5	5	200	200	200	200	200	200	200	200	
LSE6	6	6	200	200	200	200	200	200	200	200	
LSE7	7	7	200	200	200	200	200	200	200	200	
LSE8	8	8	200	200	200	200	200	200	200	200	
#LSEDataFixedDemandEnd											

Verification Test Case 1: DAM Output Data

➤ **8BusTestCase1:** A test case to verify correct refreshing of initial DAM/RTM conditions

Some of the ***DAM output data*** reported in the output files xferatoames.dat and ReferenceModel.dat are presented below.

Table 1: Generation ON/OFF Status

		GenCo1	GenCo2	GenCo3	GenCo4	GenCo5	GenCo6	GenCo7	GenCo8
	InitialCondition	1	1	1	1	1	1	1	1
D1	H1	1	1	1	0	0	0	0	0
D1	H2	1	1	1	1	0	0	0	0
D1	H3	1	1	1	1	1	0	0	0
D1	H4	1	1	1	1	1	1	0	0
D1	H5	1	1	0	0	0	0	0	0
D1	...	1	1	0	0	0	0	0	0
D1	H23	1	1	0	0	0	0	0	0
D1	H24	1	1	0	0	0	0	0	0
D2	InitialCondition	1	1	0	0	0	0	0	0

Table 2: Power Generation (p.u.)

		GenCo1	GenCo2	GenCo3	GenCo4	GenCo5	GenCo6	GenCo7	GenCo8
	InitialCondition	10	10	10	10	10	10	10	10
D1	H1	10	10	6	0	0	0	0	0
D1	H2	10	10	10	6	0	0	0	0
D1	H3	10	10	10	10	6	0	0	0
D1	H4	10	10	10	10	10	6	0	0
D1	H5	10	6	0	0	0	0	0	0
D1	...	10	6	0	0	0	0	0	0
D1	H23	10	6	0	0	0	0	0	0
D1	H24	10	6	0	0	0	0	0	0
D2	InitialCondition	10	6	0	0	0	0	0	0

Verification Test Case 1: RTM Output Data

➤ **8BusTestCase1:** Output demonstrating correct refreshing of initial RTM conditions.

Some of the **RTM output data** reported in the output files rt-unitcommitments.dat and RTReferenceModel.dat are presented below.

Table 3: Generation ON/OFF Status

		GenCo1	GenCo2	GenCo3	GenCo4	GenCo5	GenCo6	GenCo7	GenCo8
	InitialCondition	1	1	1	1	1	1	1	1
D2	H1	1	1	1	0	0	0	0	0
D2	H2	1	1	1	1	0	0	0	0
D2	H3	1	1	1	1	1	0	0	0
D2	H4	1	1	1	1	1	1	0	0
D2	H5	1	1	0	0	0	0	0	0
D2	...	1	1	0	0	0	0	0	0
D2	H23	1	1	0	0	0	0	0	0
D2	H24	1	1	0	0	0	0	0	0

Table 4: Power Generation (p.u.)

		GenCo1	GenCo2	GenCo3	GenCo4	GenCo5	GenCo6	GenCo7	GenCo8
	InitialCondition	10	10	10	10	10	10	10	10
D1	H1	10	4.2	0.8	1	0	0	0	0
D1	H2	10	4.2	0.8	1	0	0	0	0
D1	H3	10	3.8	0.8	1	1	0	0	0
D1	H4	10	2.2	0.8	1	1	1	0	0
D1	H5	10	6	0	0	0	0	0	0
D1	...	10	6	0	0	0	0	0	0
D1	H23	10	6	0	0	0	0	0	0
D1	H24	10	6	0	0	0	0	0	0

Verification Test Case 1: Summary

■ 8BusTestCase1

➤ Observations

- ✓ From Table 1's entries **D1-H24** and **D2-InitialCondition**, it can be seen that the refreshing of the initial ON/OFF status of each generator is done aptly.
- ✓ From Table 2's entries **D1-H24** and **D2-InitialCondition**, it can be seen that the refreshing of the initial power level for each GenCo is done aptly.
- ✓ From Table 1's entries **D1: H1-H24** and Table 3's **D2: H1-H24**, it can be seen that the GenCo ON/OFF commitment status levels determined on day **D1** are correctly carried over to the RTMs held on the following day (in this example **D2**).
- ✓ From Table 1's entries **D1: H1-H24** and Table 4's entries **D2: H1-H24**, it can be seen that GenCo ON/OFF commitment status levels are maintained correctly, and that GenCo commitments determined on **D1** for the balancing of net load on the next day **D2** are determined in the most economical way (i.e. the more costly generators are dispatched at their minimum generation output levels).

➤ Conclusions

- ✓ Verified correct refreshing of initial DAM/RTM conditions for multiple-day runs.