Large Scale Simulation of Electric Power Distribution VPP Controls with Detailed Models for Building HVAC Systems

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Introduction and Major Contributions

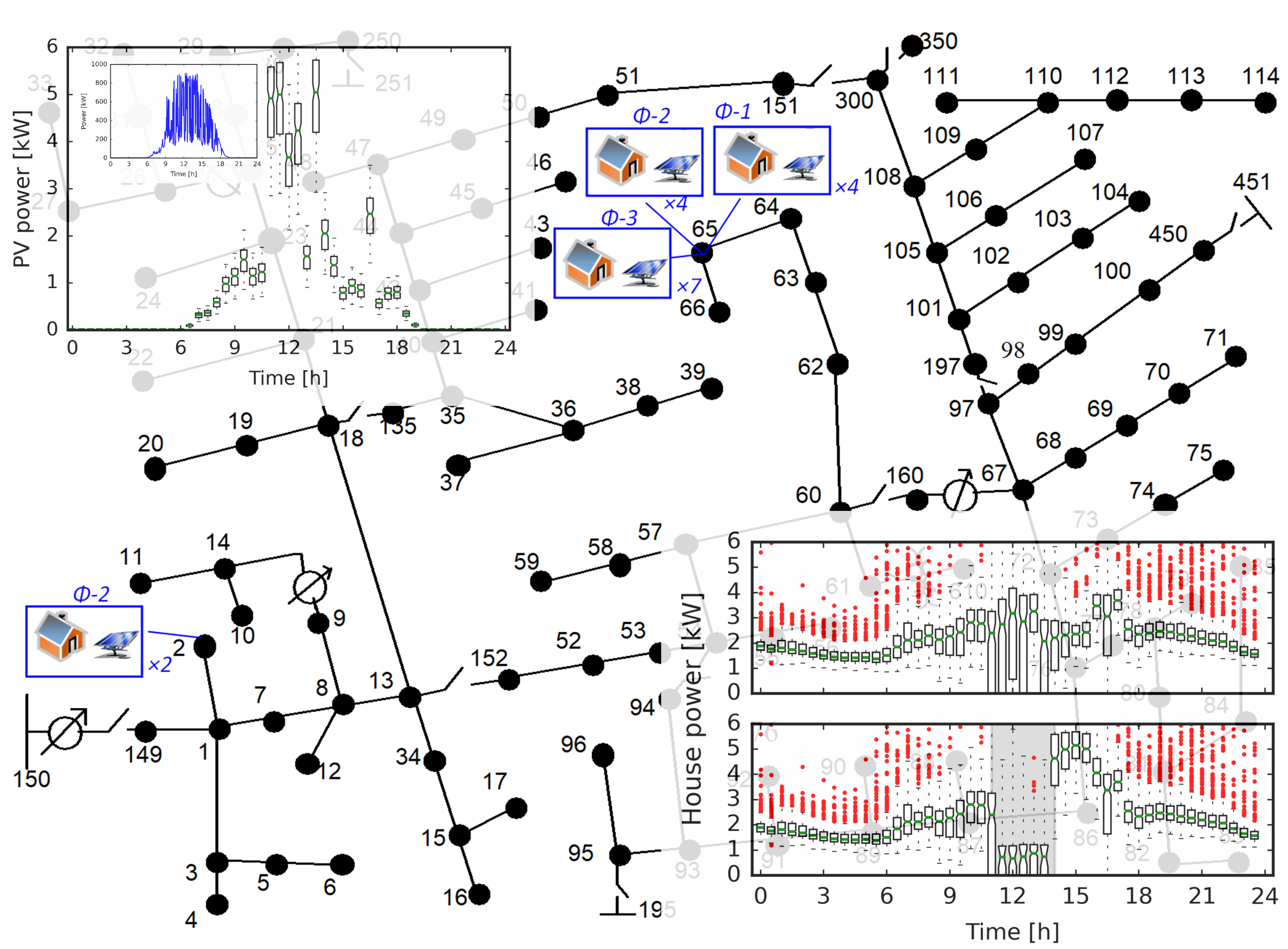
- Framework for co-simulation of open-source software and ultra-fast ML modeling, which provides accurate models of both buildings and power distribution systems
- DR command of HVAC systems considering indoor temperature and occupant comfort
- Scalability and modularity in developing and simulating many unique and realistic building models.

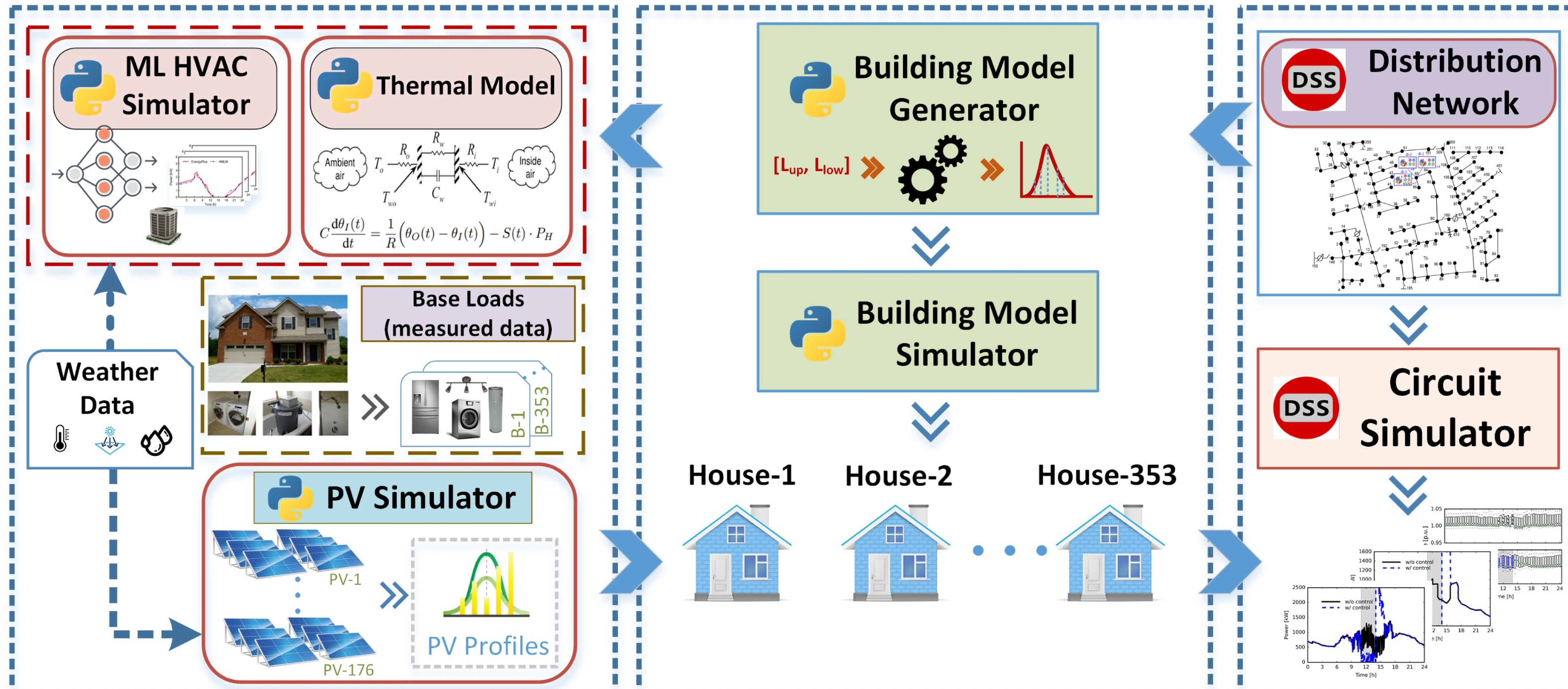
Ultra-fast HVAC and Building Models

- Ultra-fast HVAC ML models were trained upon synthetic data produced by EnergyPlus white-box energy models that were validated with experimental data
- Original houses from which data was measured were modeled to represent energy profiles ranging from high to lower efficiencies, namely near net-zero-energy (NNZE), retrofit, and conventional
- Satisfactorily accurate for both **electric power** and **inside temperature** simulation, thus enabling the tracking and prediction of **thermal comfort for occupants**
- Utilizing the hybrid ML models instead of the original white box versions enables considerably faster simulation and easier integration into software frameworks.

Co-simulation Framework

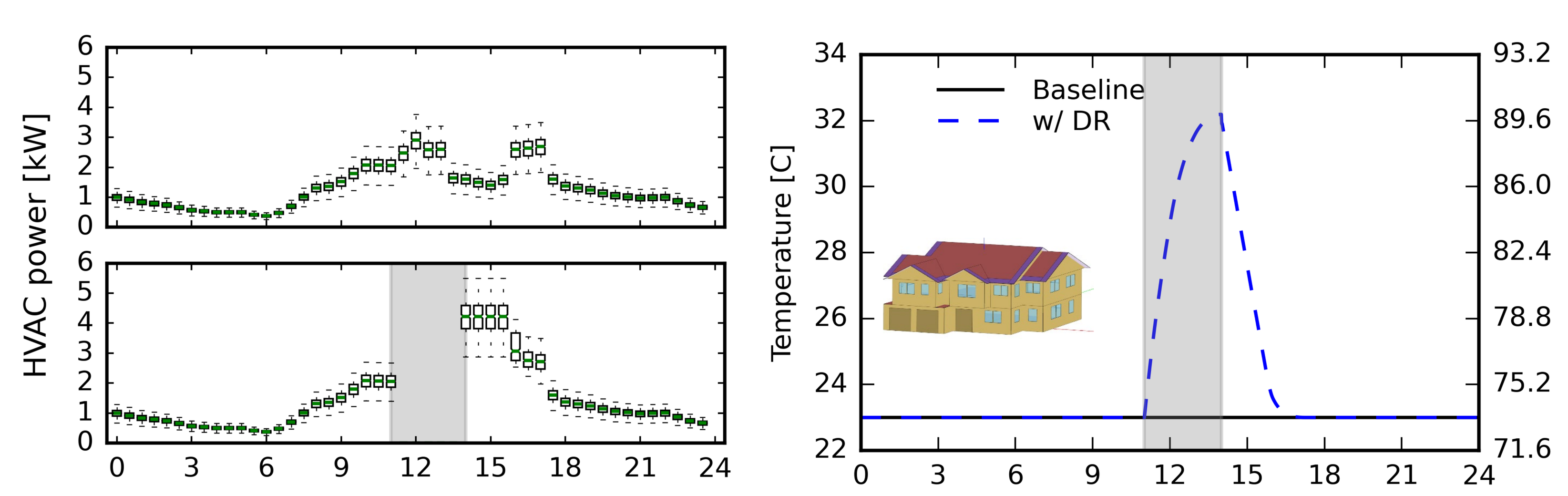
- Novel co-simulation framework that employs many software features, including OpenDSS and ultra-fast hybrid HVAC system machine learning (ML) and building thermal envelope models
- Acts as a test bed for demand response (DR) control and DER deployment.

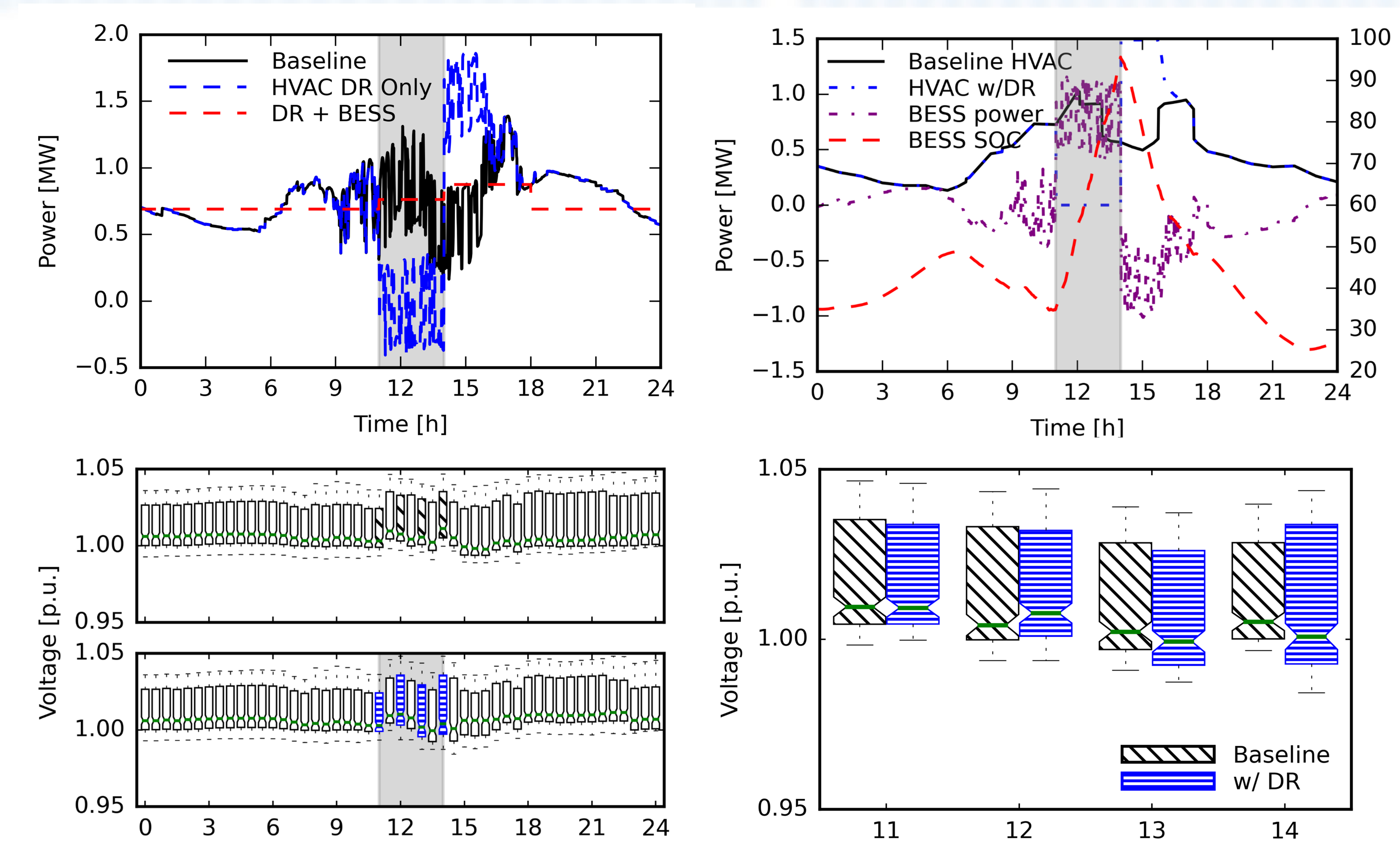




Example Distribution System Case Study

- Building models randomly populated at appropriate connection nodes throughout a modified IEEE 123 bus test system
- Initial load administration of the test system considered by assuming 10kW corresponds to a single building
- VPP simulations with conventional HVAC control time limit and thermal comfort monitoring
- Individual buildings operated with realistic power variation between models, and the power for each building reducing to the sum of the corresponding baseload and PV generation, excluding HVAC power, during the control period
- The total system power shows the large drop in power at an aggregate level during the control period and sharp increase as it ends.
- Bus voltage variations were minimal and remained within the acceptable levels of 0.95 to 1.05p.u for both cases.





Conclusions

- Framework successfully enables co-simulation and DR control of building, DER, and distribution system models
- Proven capability of analysis for individual building electric power and indoor temperature as well as power distribution system electric powerflow and bus voltages.

Acknowledgement

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