

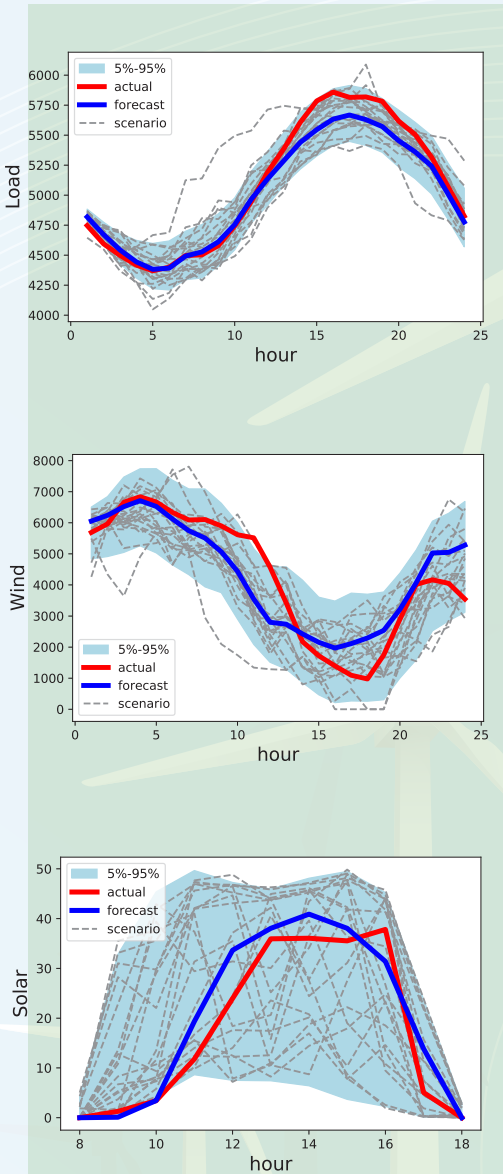


ORFEUS: Operational Risk Financialization of Electricity under Stochasticity

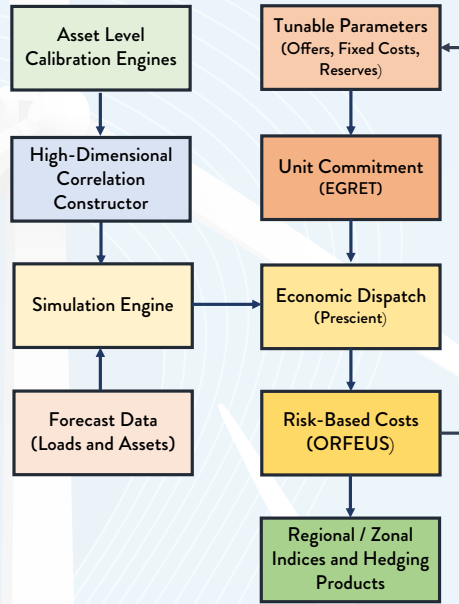
OBJECTIVE:

Modern electricity markets face new sources of risk as renewables footprint increases, and price formation in the traditional sense will ultimately be subordinated to reliability quantification. The ORFEUS platform ascribes risk and costs to each asset's contribution to system operational cost. Its major components include:

1. Nodal load and generation scenarios
2. Analysis of system operation costs
3. Risk allocation and construction of system risk indices
4. Securitization and risk transfer



From top to bottom, examples of large sets of Loads, wind, and solar power actuals, forecasts, and Monte Carlo scenarios from our models for the South ERCOT weather zone.

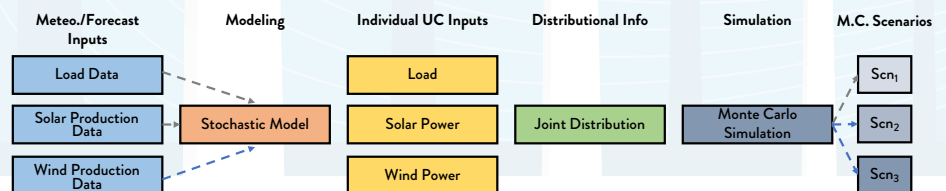


A STOCHASTIC MODEL CAPTURING CORRELATIONS

Renewable energy resources reduce carbon footprint and marginal cost, but also introduce risk to the grid that is not fully accounted for under current operational paradigms. The fulcrum of the ORFEUS platform is a set of asset-specific modules which calibrate stochastic models of the joint behavior of forecasted and actual production, tailored to wind, solar and load. Models are linked through a high-dimensional correlation constructor which renders spatial and temporal correlation structure tractable via LASSO-based methods and parametric representations of locational correlation structure (Gaussian Random Fields). The last figure shows examples of graphical LASSO correlation effects for NYISO and ERCOT zonal load forecast errors.

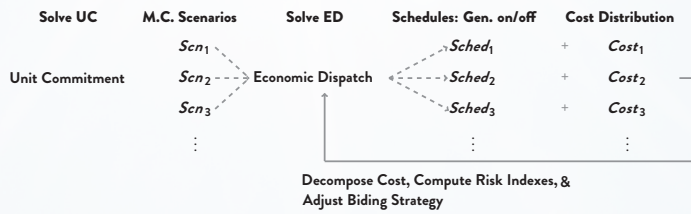
A MONTE CARLO SIMULATION PLATFORM

The ORFEUS simulation module takes the correlated asset models and produces large batch simulations. We focus on generating day-ahead scenarios at the 15- and 60-minute scale based on realistically coupled production and demand realizations based upon the forecasts available at run time. These simulations are critical inputs to existing SCUC and SCED software from which reliability cost indices are then constructed.





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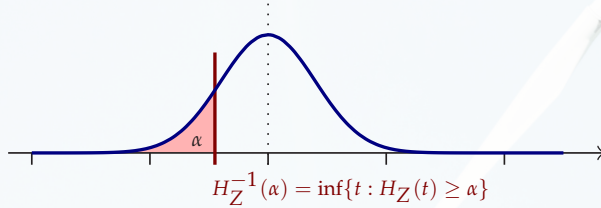


IMPLEMENTATION

1. Top-down monetary risk assessment based on system-level risk index
2. Distributes the global risk measure equitably to the zonal and asset levels
3. Organically incorporates “fairness”, “stability” and monetary operation cost
4. Reliability cost viewed as a conditional quantity, ascribed relative to overall grid and accounting for the externalities due to uncertain production
5. Sensitivity analysis of incorporating the risk allocation vis-a-vis BAU

FINANCIAL RISK MEASURES RELIABILITY INDICES

Zero-marginal-cost assets are usually guaranteed to be committed even if they create potentially costly externalities due to uncertain production. The ORFEUS risk-based cost module rigorously decomposes the results of the simulation batch into reliability costs by asset and zone using coherent risk measure methodologies ensuring that system operations allocate realized costs equitably.



RISK TRANSFER AND SECURITIZATION

The ORFEUS platform will serve as a basis for new ISO-administered products that transfer payments to “reliability enhancers” from loads and assets that contribute to system risk. Cost indices provide a vehicle by which project developers can hedge reliability risk, ultimately yielding products that will routinely be traded by dealers and listed on commodities futures exchanges.

TRANSITION TO MARKET AND PILOT

The ORFEUS team and Industry Advisory Board are well-positioned to deploy and test the platform in production settings, ultimately launching Princeton Grid Analytics as the commercial delivery vehicle.

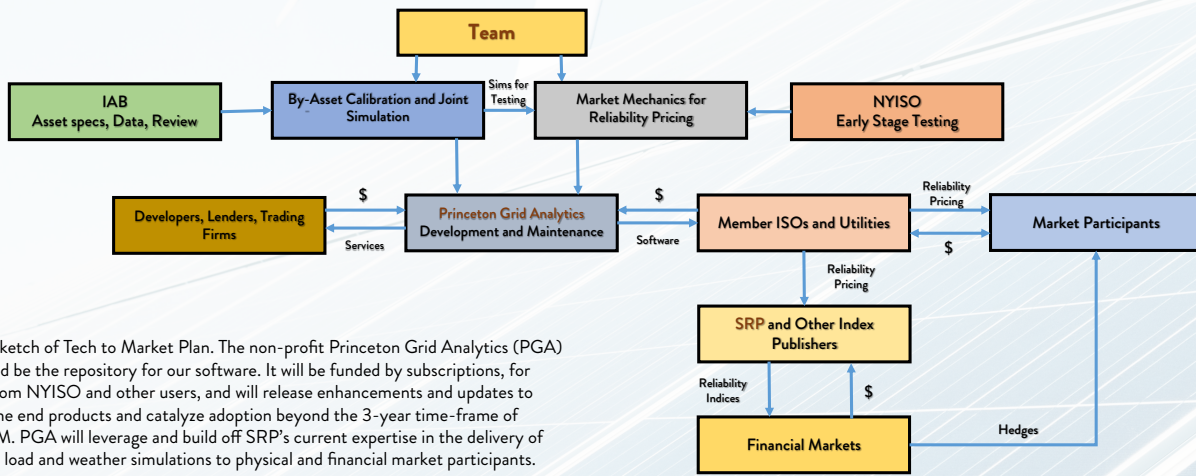
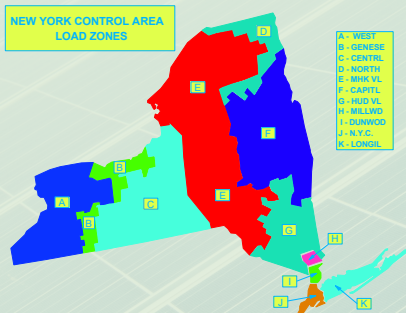
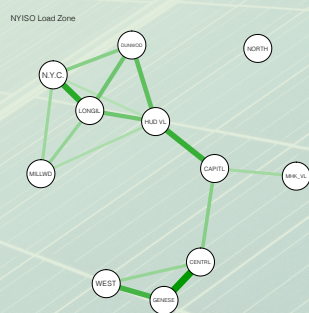


Figure 1: Sketch of Tech to Market Plan. The non-profit Princeton Grid Analytics (PGA) will own and be the repository for our software. It will be funded by subscriptions, for instance from NYISO and other users, and will release enhancements and updates to maintain the end products and catalyze adoption beyond the 3-year time-frame of PERFORM. PGA will leverage and build off SRP’s current expertise in the delivery of large-scale load and weather simulations to physical and financial market participants.



NYISO load zones (left) and correlation (right)



ERCOT load zones (left) and correlation (right)