Improving Student Understanding of the Grid via Simulating Constrained Dispatch

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Our goal is to develop insight into student learning of power systems through electricity grid game play by providing a more realistic scheduling framework. Scheduling is a key aspect of grid operations. Power plants can not be scheduled ad hoc. Power plant scheduling must adhere to a multitude of physical, economic, social, and ecological constraints. This project replaces the current proportional scheduling algorithm with a constrained power plant dispatch and optimization framework. A dispatch algorithm was researched, developed, and then implemented in the grid simulation game.

Objective

Improve student understanding of tradeoffs in grid planning and operations via providing a more realistic power plant scheduling algorithm. Improve existing proportional scheduling algorithm with dispatch optimization framework based on real world constraints.

Methodology

Explore optimization, dispatch, renewable dispatch → Explore C#, solver library opts, Griddle code base → Problem formulation & algorithm development. → Algorithm testing in R → Implement in Griddle, test through game play → Platform compatibility testing & debug

Problem & Algorithm Formulation

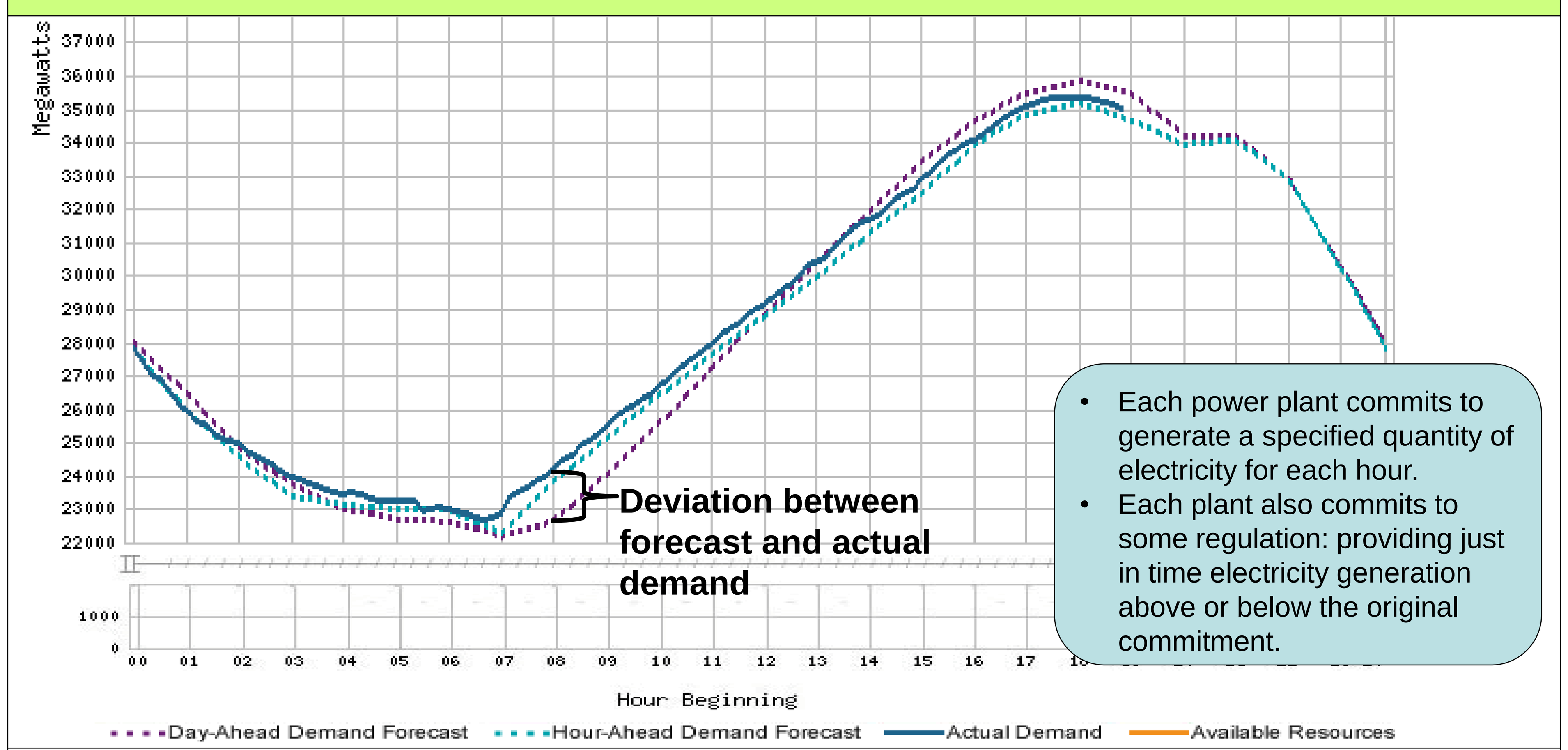

Fig. 1: California forecasted and actual demand for a sample day(1). Grid frequency stability & equipment safety require electricity generation = demand. Demand is relatively predictable at the macro scale, but even hour-ahead forecasting varies significantly from actual demand, necessitating regulation. See inset above.

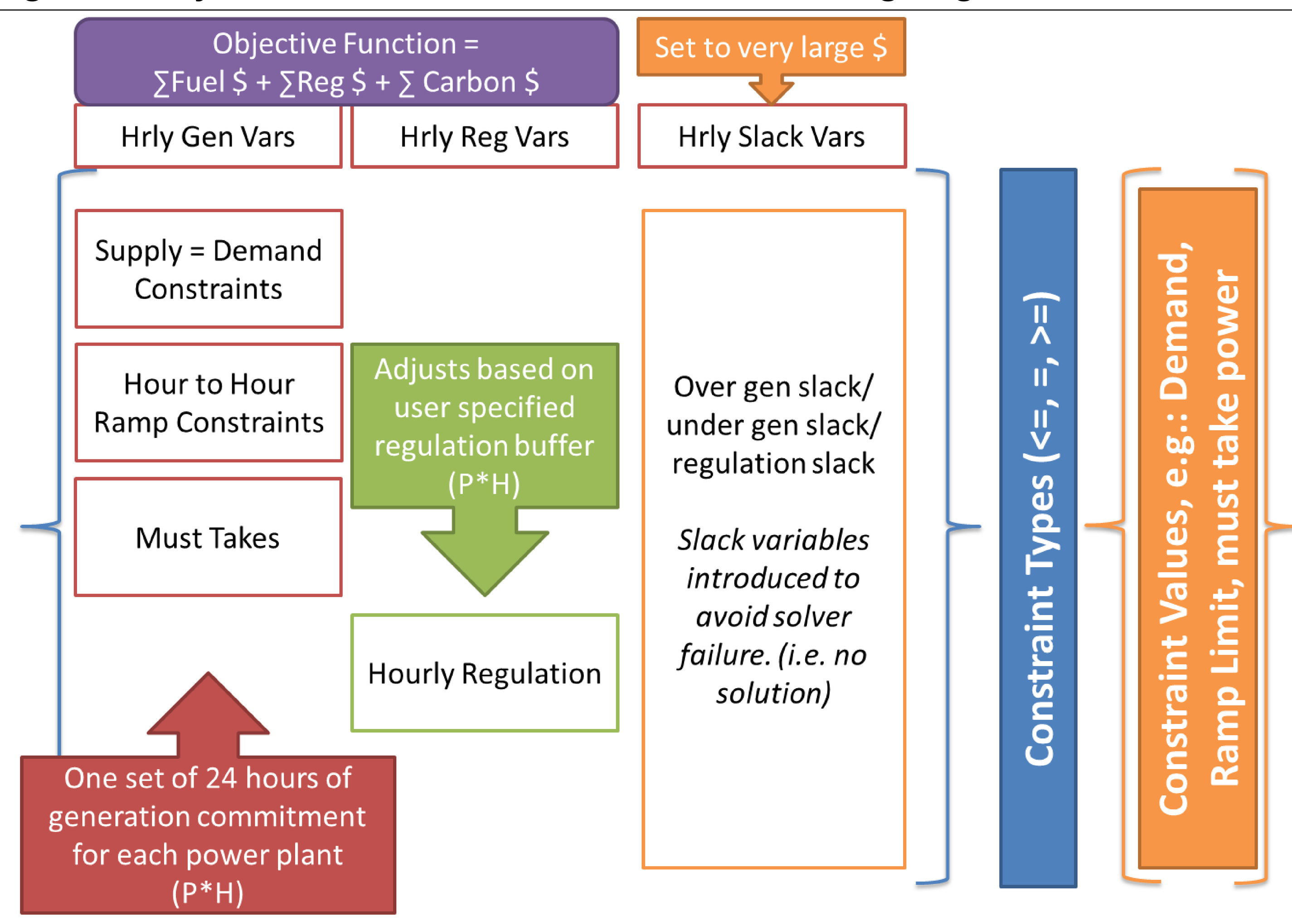

Fig. 2: Dispatch optimization involves mixed integer linear programming (MILP)(2). Block diagram of optimization implemented as a MILP in C#, using lpsolve(3).

Results

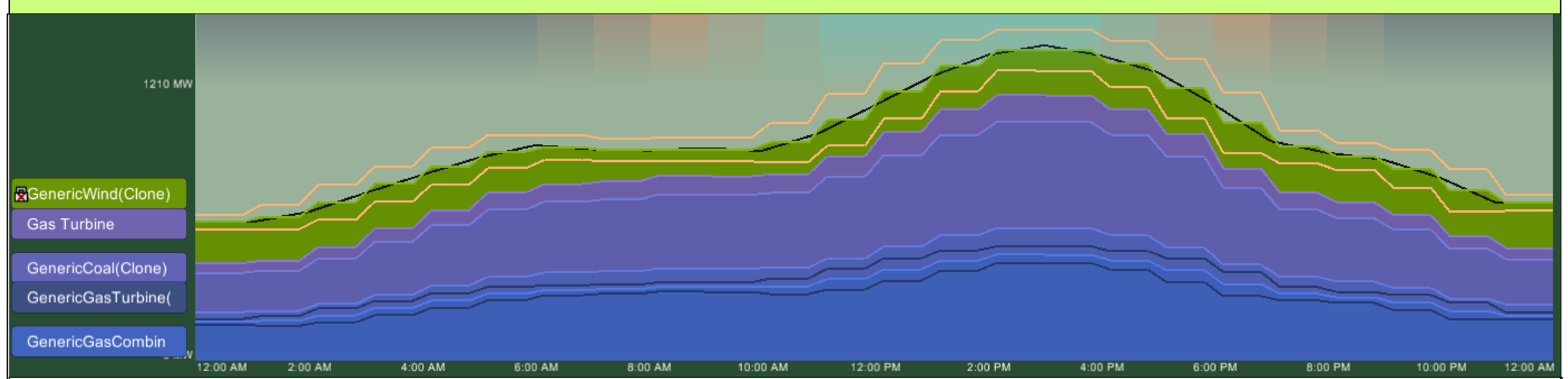

Fig. 3: Prior to this project: Dispatch using proportional scheduling. Each power plant is dispatched in proportion to its size and the hour's load. Note: wind is considered "must take", meaning if available, it must be used.

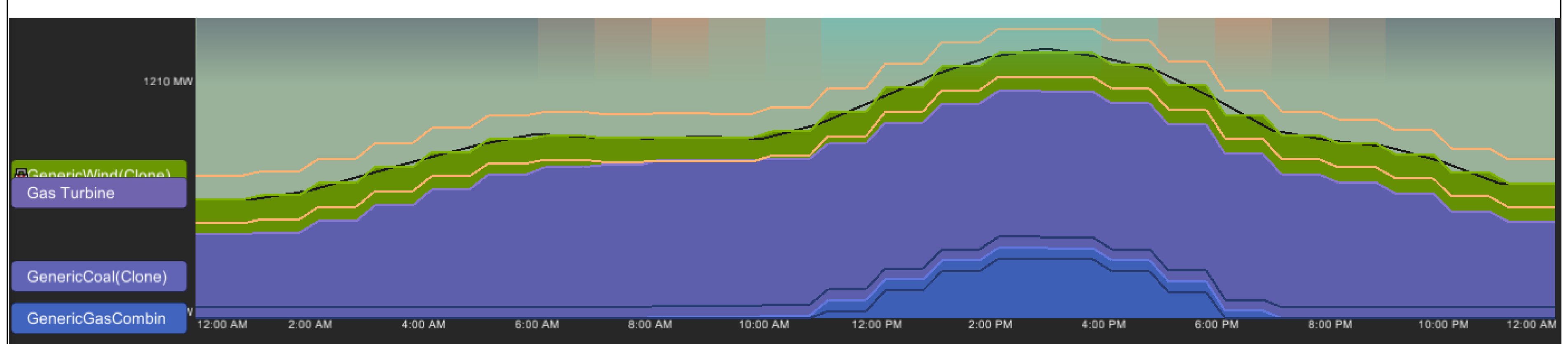

Fig. 4: After this project: Dispatch using constraints. Plants dispatched based on generation capacity, ramping ability & fuel cost. Note: coal is dispatched to a much larger amount due to its lower fuel cost. With a sufficient carbon tax enabled, we would expect coal dispatch to be reduced due to coal's significant carbon emissions.

- Provide player (or student) with a more realistic scheduling algorithm to enable training players with respect to key grid constraints and dynamics.
- Dispatch optimization successfully implemented in Griddle on 3 main platforms: Windows, UNIX, and Mac OS X.

Future Work

- Implement regulation buffer, carbon tax, and slack in MILP.
- Create game levels that provide insight into real world tradeoffs provided through optimization parameters including: carbon tax, regulation buffer, pollution impacts, fuel costs, etc.
- Investigate impact of student learning of grid concepts in Griddle.

Acknowledgements

Hitesh Soneji thanks Michael Cohen for his vision & guidance, Prof. Callaway for providing the opportunity, and ERG for being so welcoming. Thanks also to Prof. Yuen and the E3S support staff.

References

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- (3) lpsolve Open source (Mixed-Integer) Linear Programming system. http://lpsolve.sourceforge.net/5.5/

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Support Information
This work was funded by National Science Foundation Award EEC-1405547.