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System Dynamics models for improved power plant operation planning

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***Abstract*—A modular System Dynamics model for power generation systems is presented, which can be used as a planning tool for plant control as well as a test-bed for future infrastructure policy.**

I. INTRODUCTION

One of the major challenges of electricity generation is to match demand as a function of time (load) with output. Load prediction is commonly based on existing measurement data, which cannot account for the unpredictability in human behavior and associated short-term fluctuations in demand.

Mismatching of load and output leads to decreased efficiency and increased financial costs of generation [1]. Short-term load-output mismatching necessitates the use of more expensive generators, such as peaking and load-following units, and increases dependence on hour-ahead markets [2]. Better load prediction leads to improved plant operation planning and a reduction in such mismatching. Accurate models of generation subsystem behaviors improve operation planning based on the load function.

II. METHOD

In real-world systems, the combination of many components often leads to complex behaviors that require advanced techniques to understand and predict. System Dynamics (SD) is one such computational technique for modeling complex behavior that has been successfully applied to problems in such wide-ranging fields as economics, engineering and the environmental sciences [3, 4].

Using VenSim [5] a general SD model is constructed to simulate the contributions of various components within a typical power grid generation infrastructure. These components include thermal (nominally coal) plants, a realistic load function and imports/exports with the grid-connected markets.

For policy planning purposes we include solar and wind energy sources as well as hydro-electric power plants, capable of energy storage and generation, depending on the availability of surplus energy.

This general model can be adapted to include feedback from the time-varying load to find the optimum plant operation.

III. RESULTS & DISCUSSION

Fig. 1 contains simulation results for a model with a naive load function and fixed coal plant operation, assuming non-perfect conditions such as short-term reductions in the coal generation capacity. Also included are small wind and solar power capabilities, as well as a hydroelectric store that pumps water to a reservoir when excess power is available, and releases water to generate power when more is required. At around 5 hours a load peak coincides with a reduction in coal output, leading to shortages. The hydro-electric plant releases water to compensate. On this occasion the generation rate is not sufficient, and imported power is required to match the required load. The results indicate that, for these given starting conditions, a hydroelectric store is a useful addition to the grid, in order to avoid market imports.

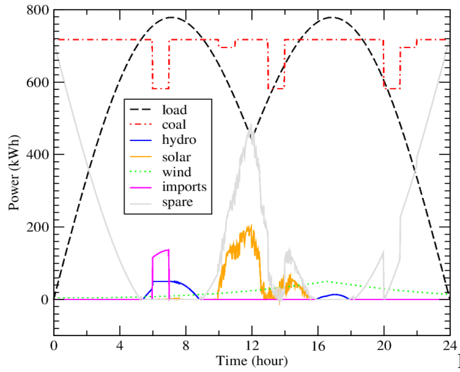

Figure 1: Model of power generation grid including naive load model, coal, solar, wind and hydroelectric power sources. Various scenarios can be tested.

IV. CONCLUSIONS

Further models currently in development include more realistic load functions and load-following plant operation planning, to be presented at IFOST 2013.

REFERENCES

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