Future Directions for Quantum Computing in Energy Systems at West Virginia University

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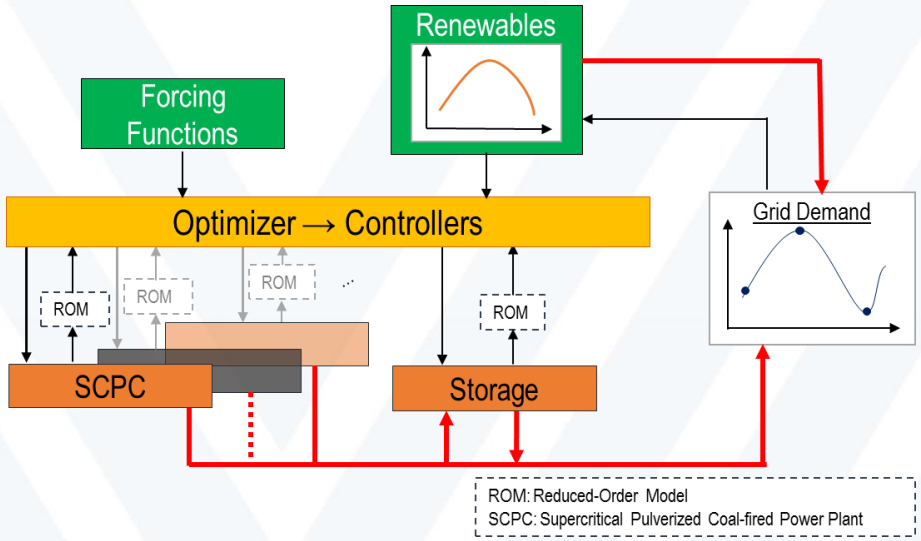
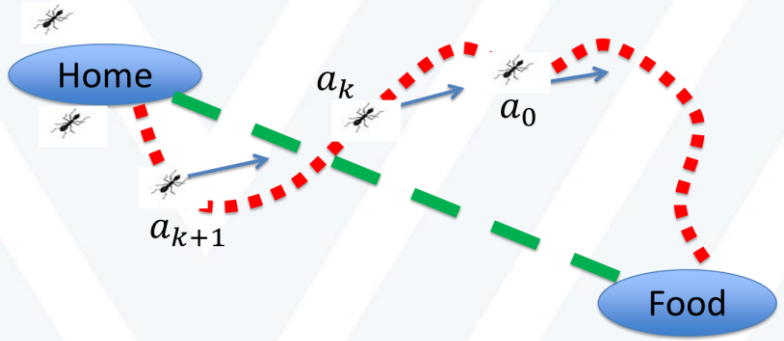
Control, Optimization and Design of Energy Systems

New approaches to control and optimization developed at WVU could benefit from quantum computing speed ups[1] (Bayesian inference, Least-squares fitting, Reinforcement Learning, etc.):

- Particle swarm optimization and sequential quadratic programming for advanced control and optimization of power plant cycling
- Neural networks, ant colony optimization and genetic algorithms for biomimetic control of hybrid energy systems
- Parallel computing for design optimization of modular energy systems



Optimization and Control for Power Plant Cycling



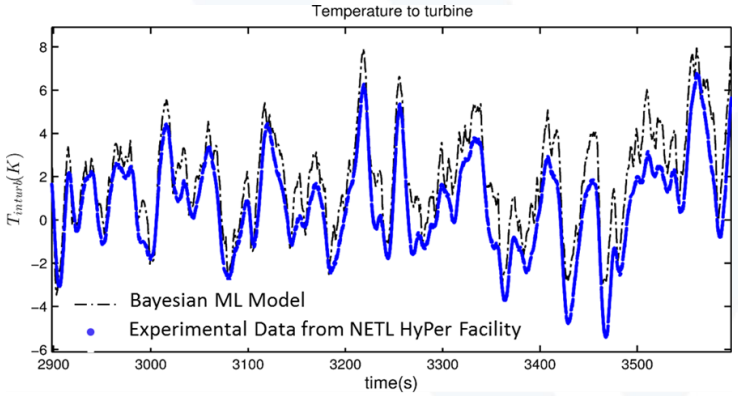
Biomimetic Control for Energy Systems Applications

[1]Biamonte, Wittek, Pancotti, Rebentrost, Wiebe, and Lloyd, Nature **549** (2017)

Optimizing Efficiency, Reliability, and Resiliency of Existing Energy Systems

Bayesian Machine Learning

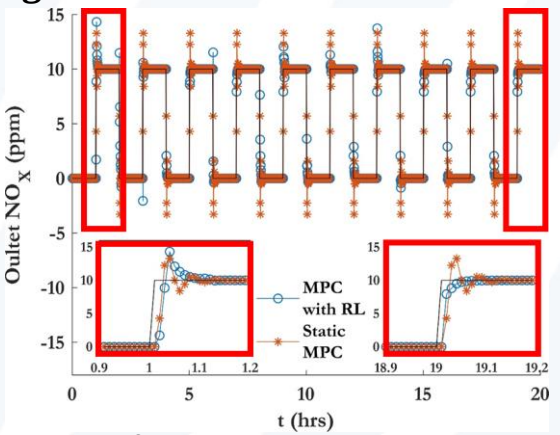
- A Bayesian ML framework has been developed for learning time-varying stochastic systems.
- This approach is being applied to estimate ash deposit and internal scaling in the boiler of fossil plants



Performance of the Bayesian ML Models for the NETL, Morgantown HyPer Facility

Gaussian Radial Basis Function Network for Probabilistic Model Building and Reinforcement Learning

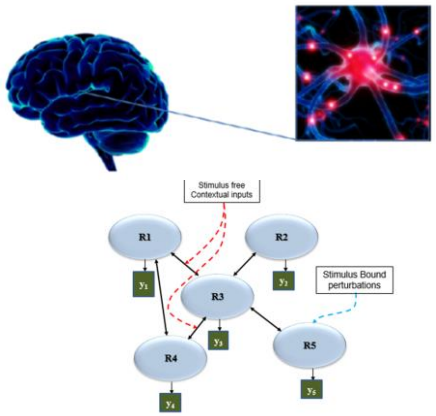
- A probabilistic network that is being used for predicting failure probabilities of boiler components
- Developing novel RL algorithms that learn the control policy of fossil plants as system evolves



A RL for a Selective Catalytic Reduction System for a PC Plant

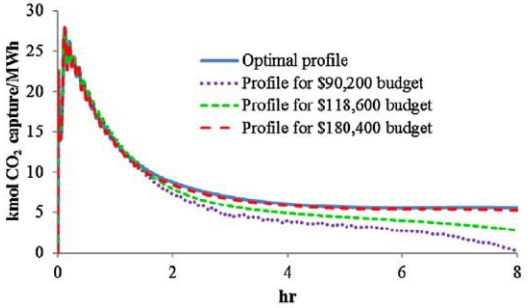
AI Approaches to Controlled Variable Selection and Process Control

- Developing AI approaches drawing from neuroscience
- Applying to process optimization, controlled variable selection, process control, and monitoring



Large-Scale Mixed Integer Nonlinear Optimization for Fossil Plants

- Optimal selection of variables for control and monitoring of fossil plants lead to large scale optimization problems
- Bayesian optimization is costly-using cloud computing



Transient Performance of an Optimal Sensor Network for a Fossil Plant with CO_2 Capture

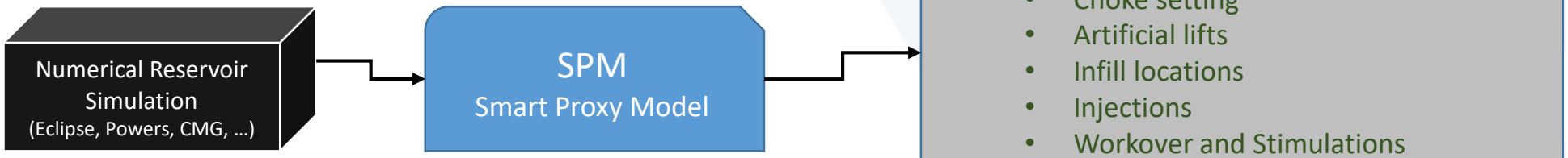
Optimizing Efficiency and Management of Oil and Natural Gas Extraction

First scientific paper on applications of machine learning in petroleum management was published in 1993 by faculty of Petroleum Engineering at West Virginia University

AI&ML in the oil and gas market is expected to grow from an estimated $1.57 Billion in 2017 to $2.87 Billion by 2020.

Typical example is Reservoir Analytics: Smart Proxy Modeling

- A reservoir management tool for field development planning
- Model has a small computational footprint but is deterministic.
- Limited ability to learn from large data sets and simulations. Really a reductionist model. Deep quantum learning approach would enable full use of models and field data.



SPM replicates Numerical Reservoir Simulation at well and grid block levels – Provides Results in seconds.

- Quick Screening of potential solutions.
- Field Development Planning
- Design and Optimization of:
  - Choke setting
  - Artificial lifts
  - Infill locations
  - Injections
  - Workover and Stimulations
  - etc.
- Quantification of Uncertainties

Pressure and Saturation distribution at different reservoir layers.