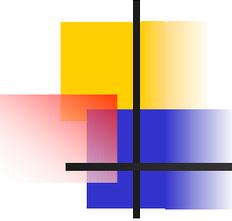


# The Curse of Dimensionality

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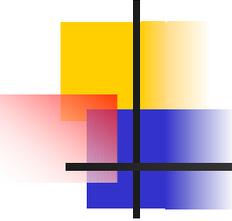
Edward G. Cazalet  
SSG-WI Modeling Workshop  
Portland OR  
September, 15, 2004



# The Three Curses

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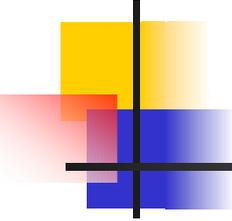
- Complexity
- Many Uncertainties
- Many Decisions



# Complexity

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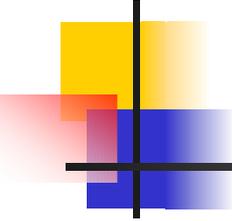
- Large, interconnected, locational networks of transmission, generation and load with complex, nonlinear physics
- Time – decades, years, months, weeks, days, hours, minutes, seconds, ...
- Every thing is connected – fuels, fuel transportation, economic activity, demand and supply side devices and resources, market regulation, finance, ownership, etc.



# Uncertainty

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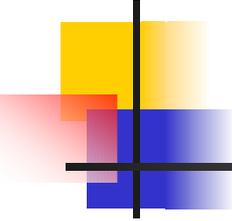
- Many uncertain variables – generation and transmission availability, fuel prices and availability, hydro inflows, transmission and generation capital costs, local and regional population and economic activity, technology change, interest rates, regulatory change, etc.
- Some variables resolve repeatedly - yearly, monthly, daily, or hourly
- Other variables resolve incrementally over years, months and days
- Some variables are correlated with others



# Many Decisions

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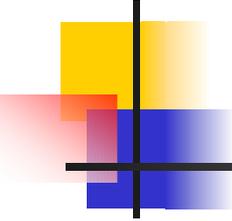
- Many *wires* paths and alternatives – DC, AC, smart devices and controls
- Many *non-wires* alternatives – generation size, type and location, demand side resources, retail pricing, load control, building design, etc.
- Many *non-power* alternatives – conservation, natural gas heating, etc.



# Breaking the Curse

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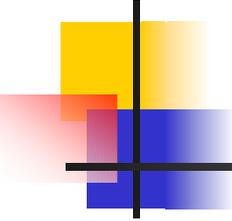
- Automated equivalencing, aggregation and sampling
- Monte Carlo randomization
- Decomposition or decentralization using price iteration
- Computers keep getting faster and cheaper



# Automated equivalencing, aggregation and sampling

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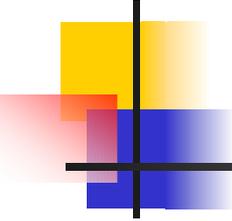
- Gather data at natural high level of physical detail
- Automate the process of network equivalencing, data aggregation and sampling time periods to run simulation at any chosen level of detail
- Use these small models to develop insight on what is important



# Monte Carlo Randomization

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- Use a hundred or so Monte Carlo games with thousands of random draws for many variables over time
- Use special techniques to generate extreme events with low probability
- Use dynamic stochastic models for variables that resolve over time
- Use approximation methods to generate state contingent forecasts for forward decisions



# Decomposition or Decentralization using Price Iteration

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- Given market or shadow prices, complex decision problems often decompose or decentralize into many easy to solve “agent” sub problems.
- Iterate on the prices until an equilibrium is achieved (dual solution)
- Supports naturally parallel processing on many fast, cheap computers