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Some experience with uncertainty analysis using MESSAGE

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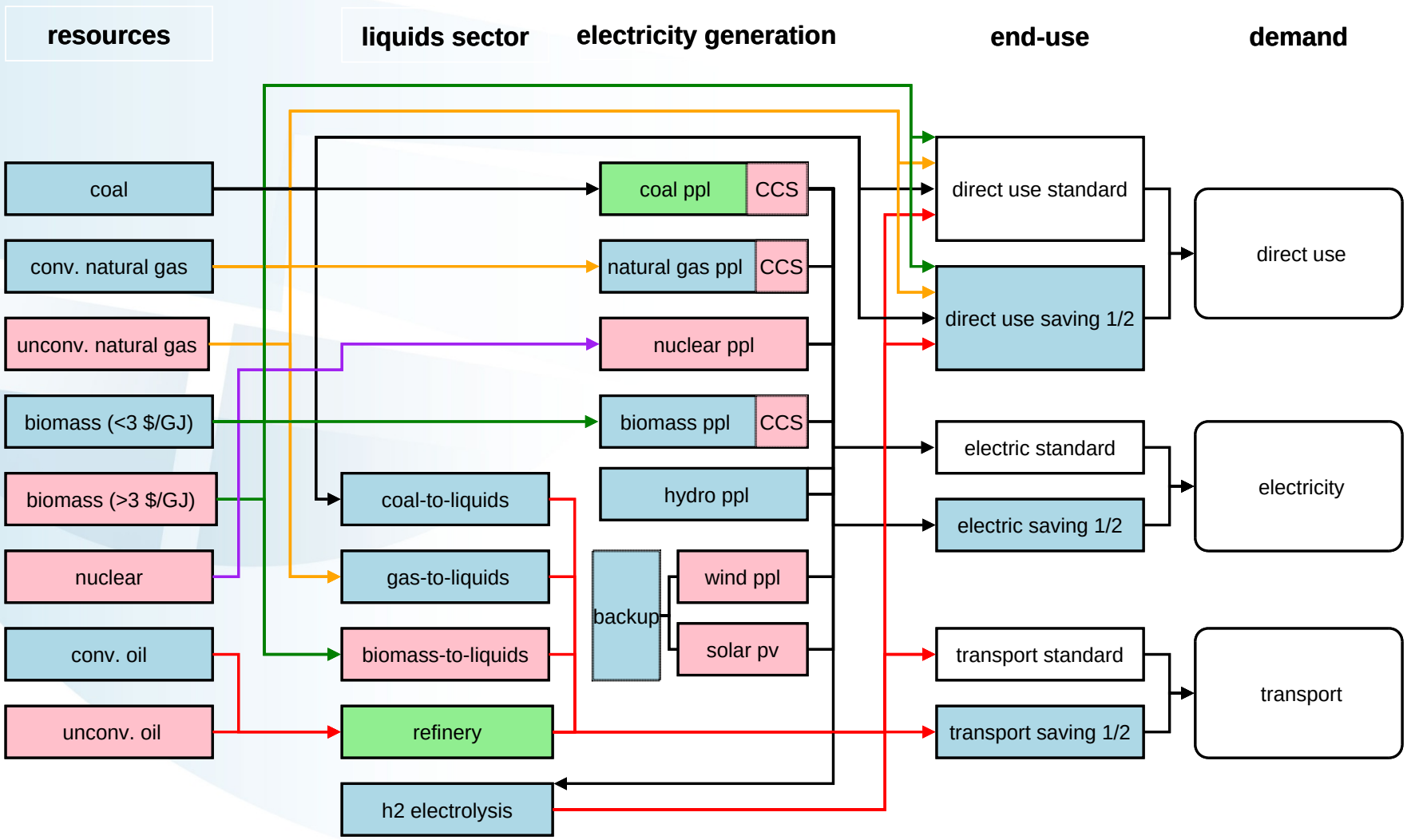
Methodology

- Optimization approach borrowed from Modern Portfolio Theory (Markowitz)
- In addition to expected cost, a risk measure (e.g., variance, downside risk, conditional value at risk) is taken into account in the optimization
- Restricted to uncertain economic parameters, i.e. all physical properties are deterministic

Reduced-form Version of MESSAGE



Uncertainty Classes: low: σ=0.15 medium: σ=0.3 high: σ=0.6

Objective function and risk measure

- Deterministic objective function (cost minimization):

$$F^{\text{det}}(\mathbf{x}) = \sum_t \bar{\mathbf{c}}_t^T \cdot \mathbf{x}_t \cdot \delta(t)$$

deterministic costs

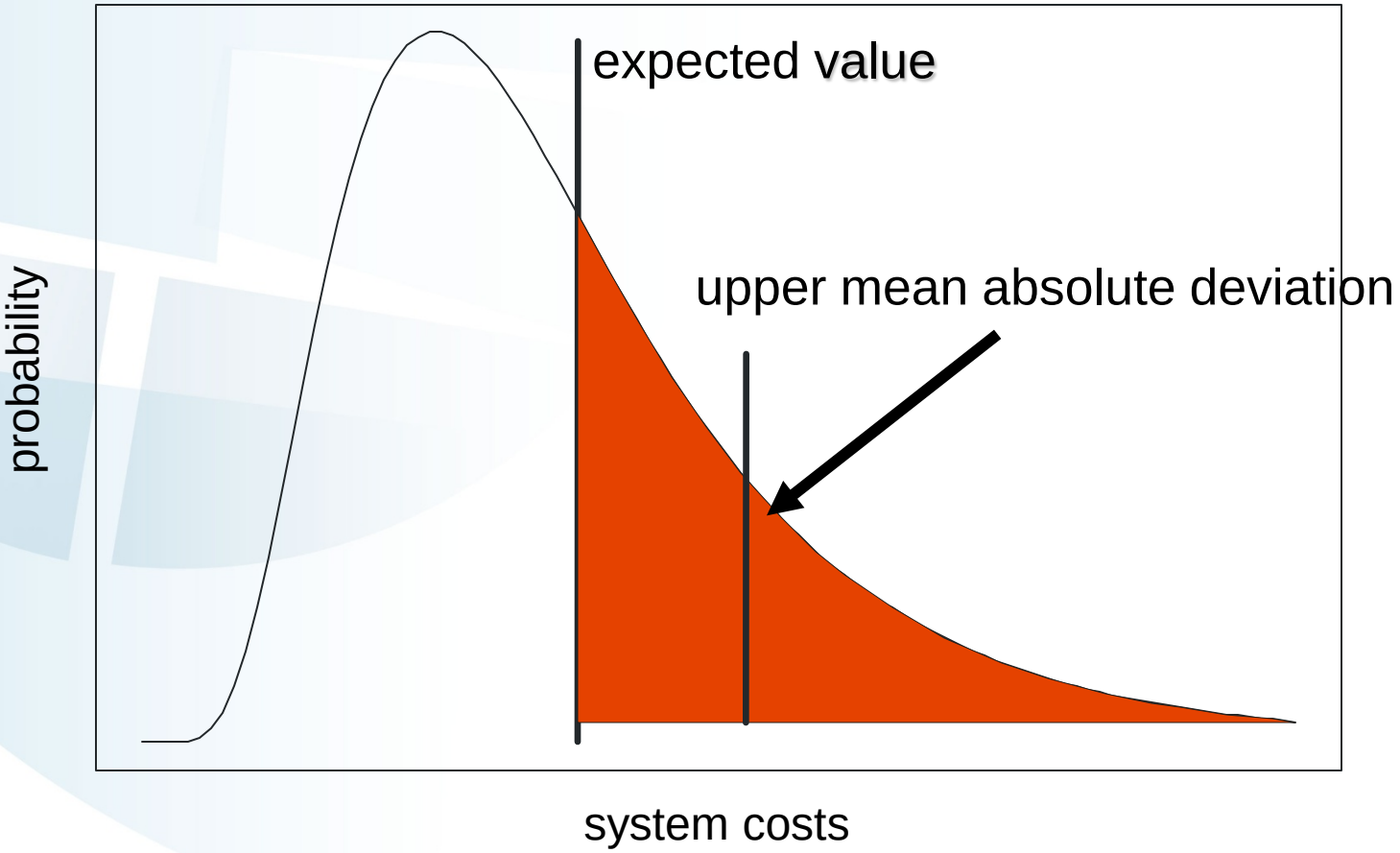
- Example for risk measure (linear)

$$\bar{R}(\mathbf{x}) = \mathbf{E}_\omega \left[\sum_t \max \left\{ 0, [\mathbf{c}_t(\omega) - \bar{\mathbf{c}}_t]^T \cdot \mathbf{x}_t \right\} \cdot \delta(t) \right]$$

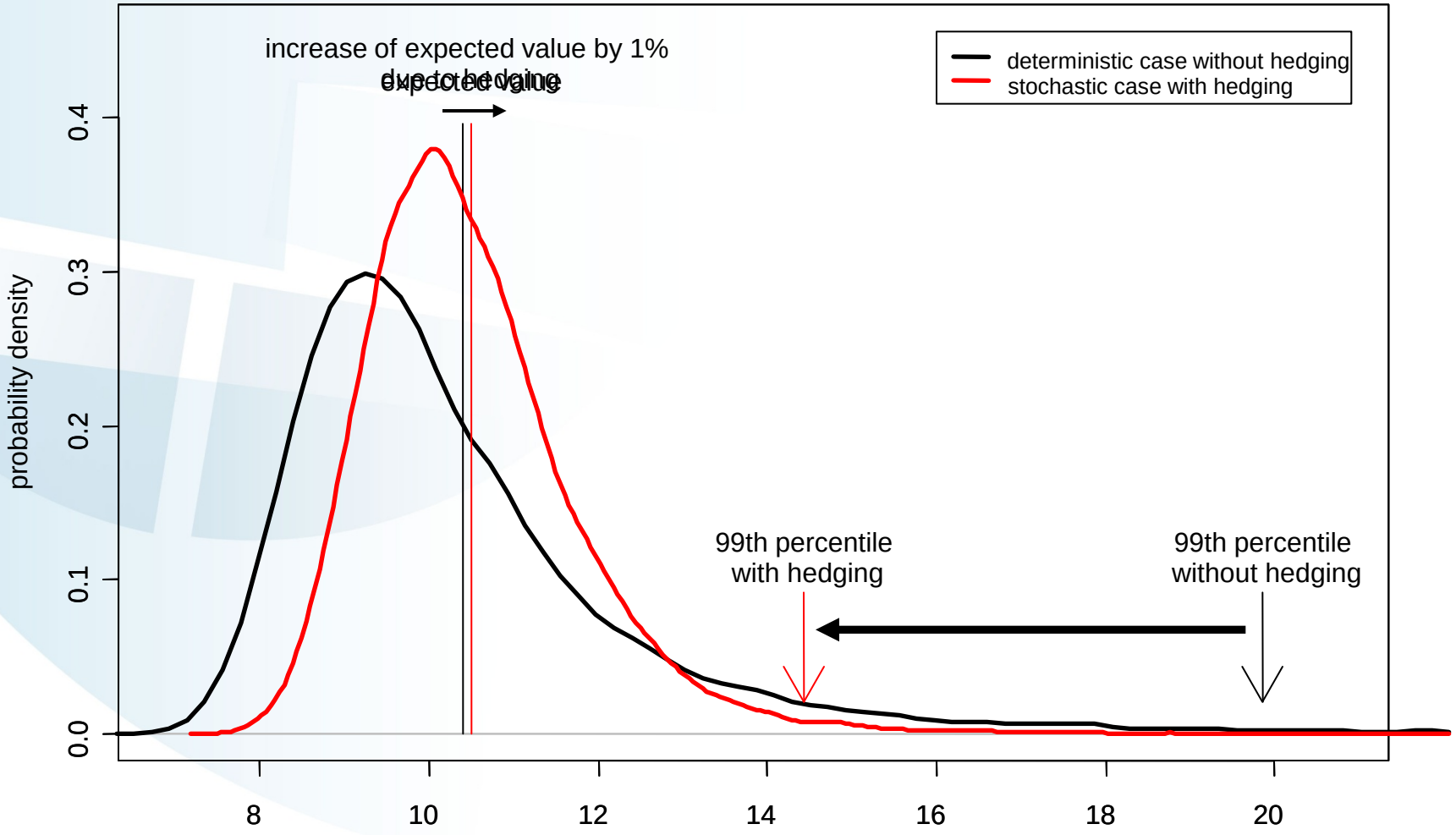
sampled from cost PDF

expected costs

Risk Measure: Upper mean Absolute Deviation

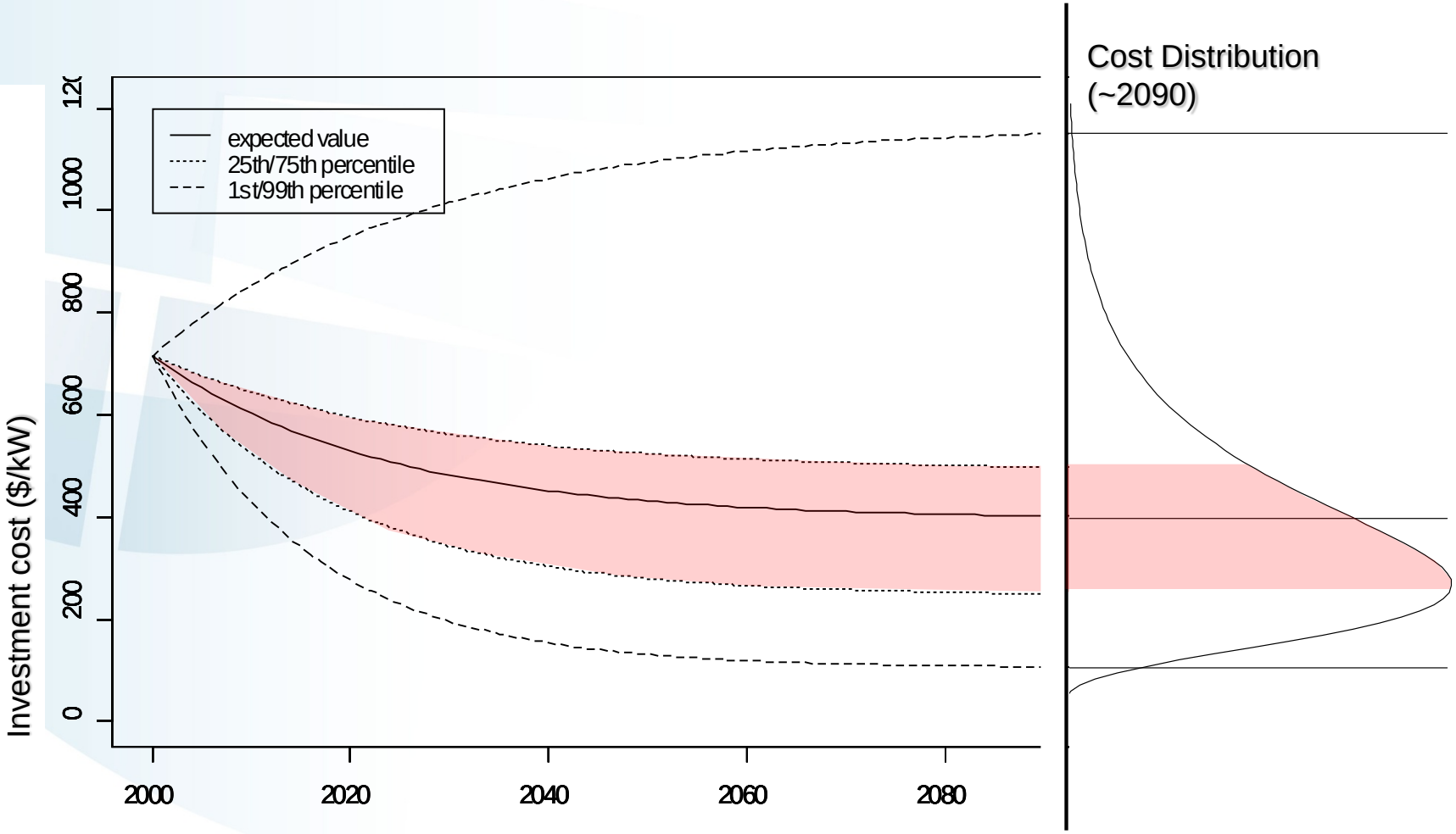


Energy System Cost PDF



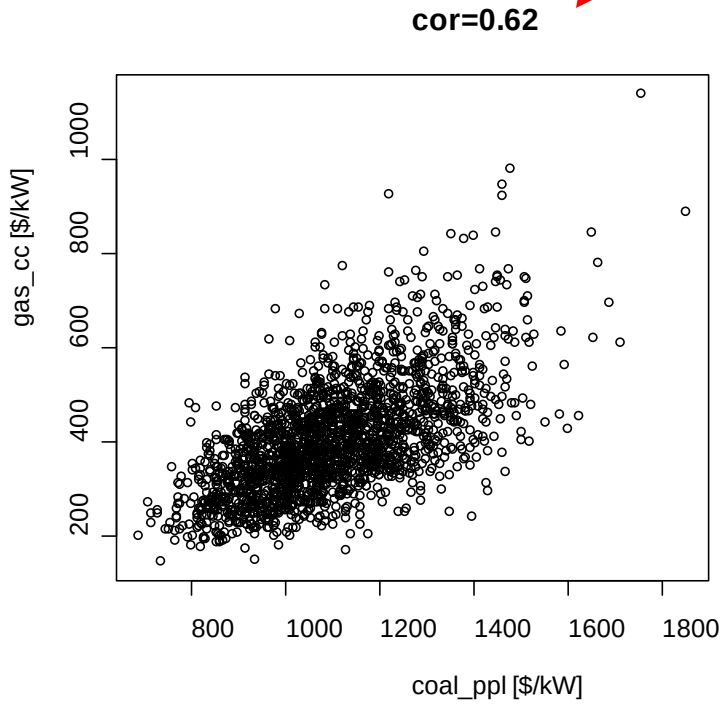
Sampling

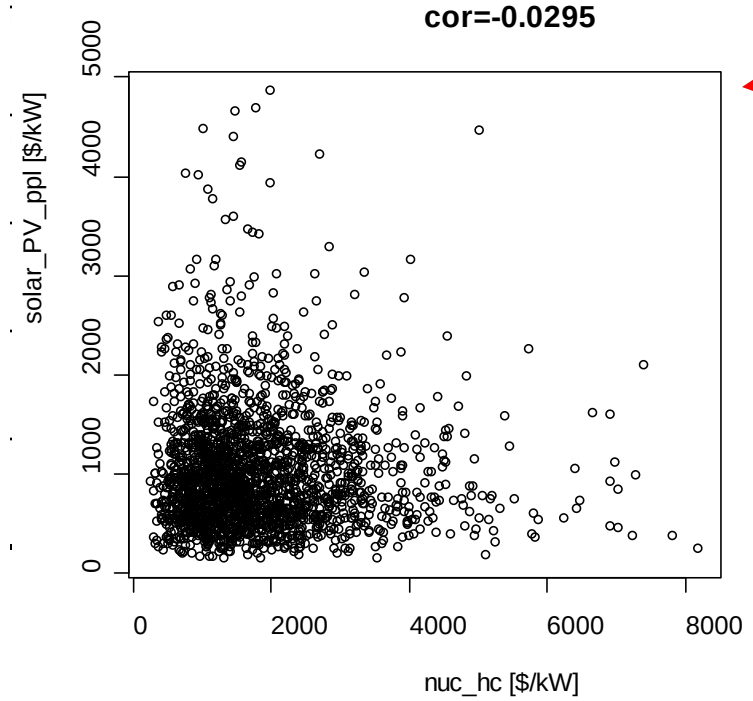
Cost Development over Time (Natural Gas Combined Cycle)



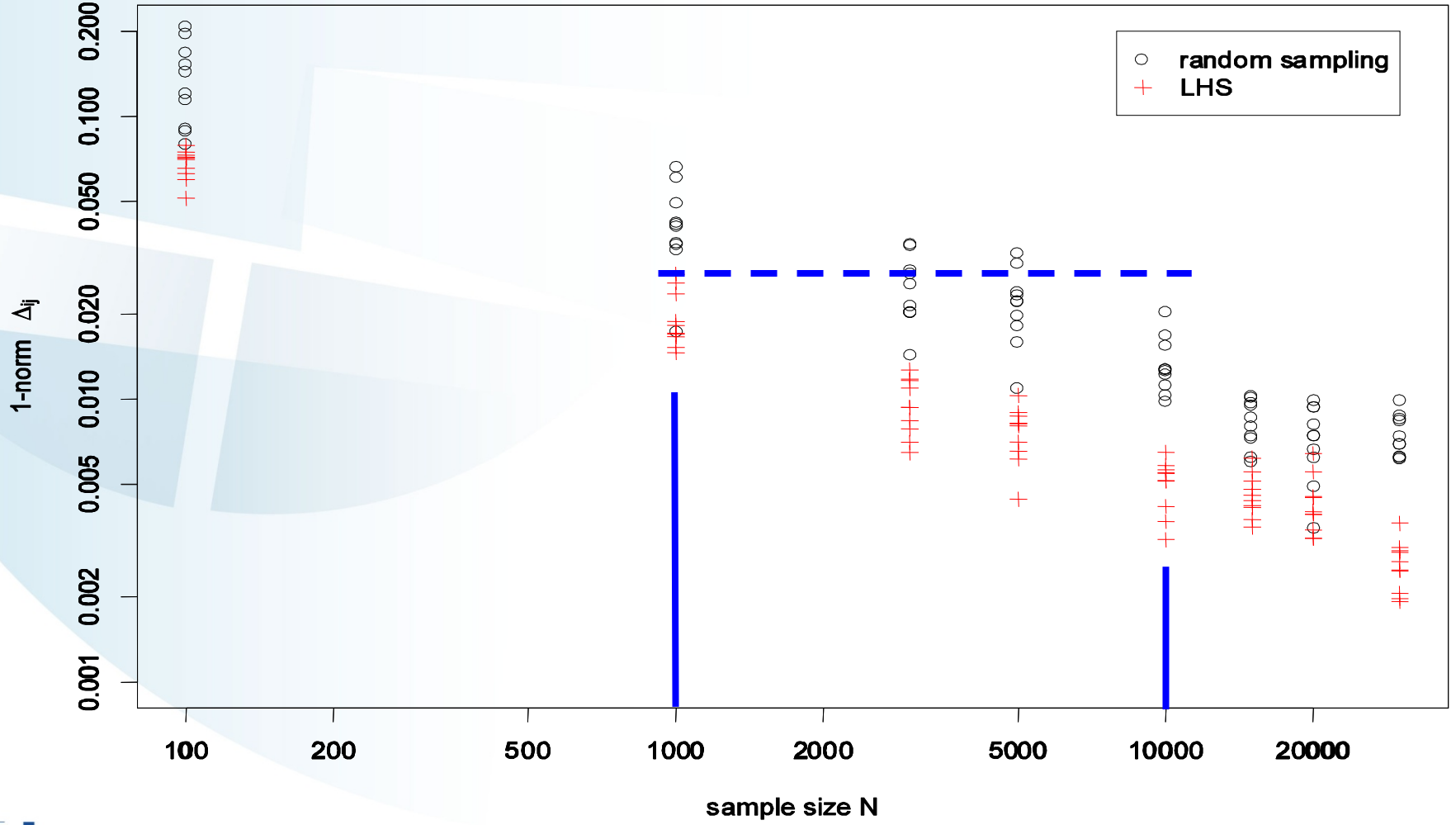
Correlation Matrix: Electricity Generation

	Coal	Gas	Nuclear	Biomass	Hydro	Wind	Solar
Coal	1	0.63	0.05	0.57	0	0	0
Gas		1	0.05	0.57	0	0	0
							0
							0
							0
							0
							0
							1





Convergence: random sampling vs. LHS



Thank you!

Convergence: sample size *N*

- 1-norm (or Taxicab norm):

$$\|\mathbf{x}\|_1 = \sum_i |x_i|$$

with:

$$\frac{\|\mathbf{x}_1 - \mathbf{x}_2\|_1}{\|\mathbf{x}_1 + \mathbf{x}_2\|_1} \leq \varepsilon$$

- sampling: random or Latin Hypercube (LHS)
- Dependence in case of LHS using algorithm by Iman and Conover (1980)
  Iman RL, Conover WJ (1980) Small sample sensitivity analysis techniques for computer models.with an application to risk assessment. Communications in Statistics - Theory and Methods 9:1749 - 1842.