TECHNISCHE UNIVERSITÄT WIEN

Optimal Policy of the Prosumer‘s Power Procurement Problem with Probabilistic Constraints

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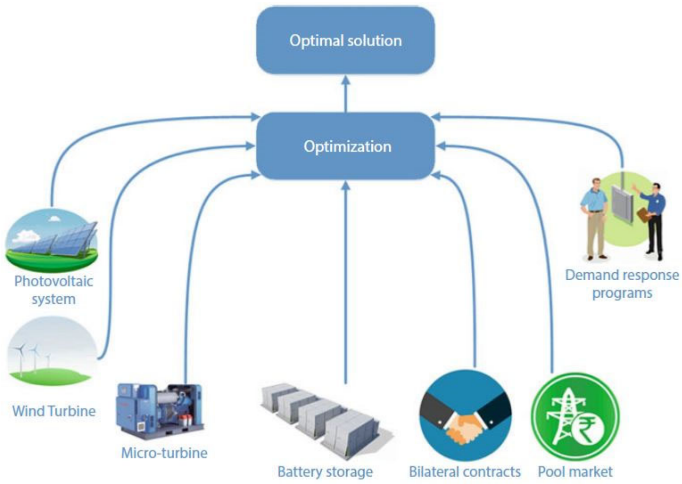
Motivation

- EU climate strategy: 2020, 2030, 2050: increase share in renewables: 20%, 32%, 75%; increasingly volatile power output
- Trend of increased focus to incorporate risk management approaches in energy planning problems (Liu et al., 2006)
- Enterprises can act as prosumers (= consumer + producer who can cover a part of his demand)
- A prosumer acting in the liberalized power market faces the *power procurement problem* (PPP)
- (PPP): Procuring the required power at minimum possible costs (Rezaeipour and Zahedi, 2017), *[...] choose best strategy by considering available sources* (Shafieezadeh at al., 2019)

Problem Statement

- PPP: different procurement options
- Deterministic modeling approach: procurement policy can be infeasible or overly expensive (Beraldi et al., 2017)
- Probabilistic PPP: Probabilistic modeling approach from prosumer's point of view via chance constraints
- Communication of solution: decision support system

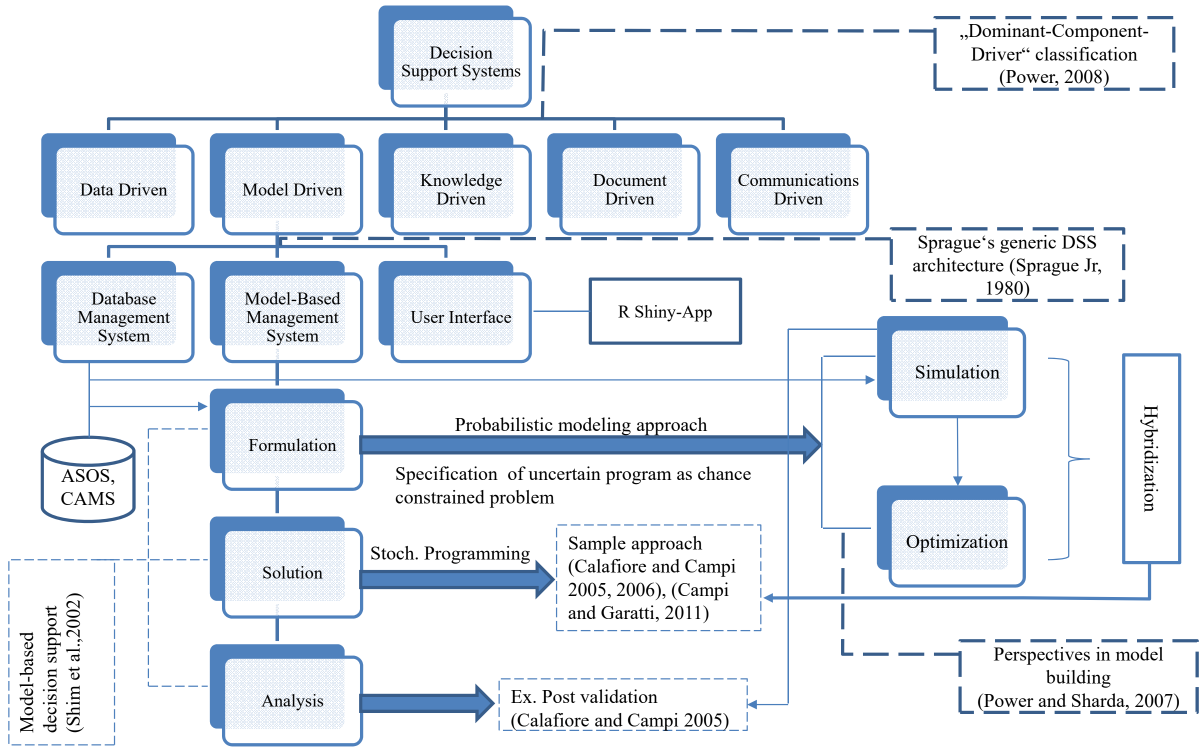
Cost minimizing solution s.t. procured power covers demand



"Research Questions"

- Design a suitable probabilistic modeling approach
  - Consider the uncertainty in the power output from different procurement options (stochastic supply-demand constraint)
  - Implements methods of *non-parametric statistics* (using empirical user-specified data)
  - Produces robust and efficient solutions of the probabilistic PPP (computational time)
- Embed this model in an interactive toolbox: support managerial decisions to enhance communication of solution via decision support system

Methodology



Methodology-Formulation

- Use Case: RES-capactiy budgeting problem to cover a part of the demand (daytime model, monthly time grid)

Det. Design

$$\min_{x \in X} f(x) \quad \text{s.t}$$
$$\sum_i x_i P_{it} \geq d_t$$

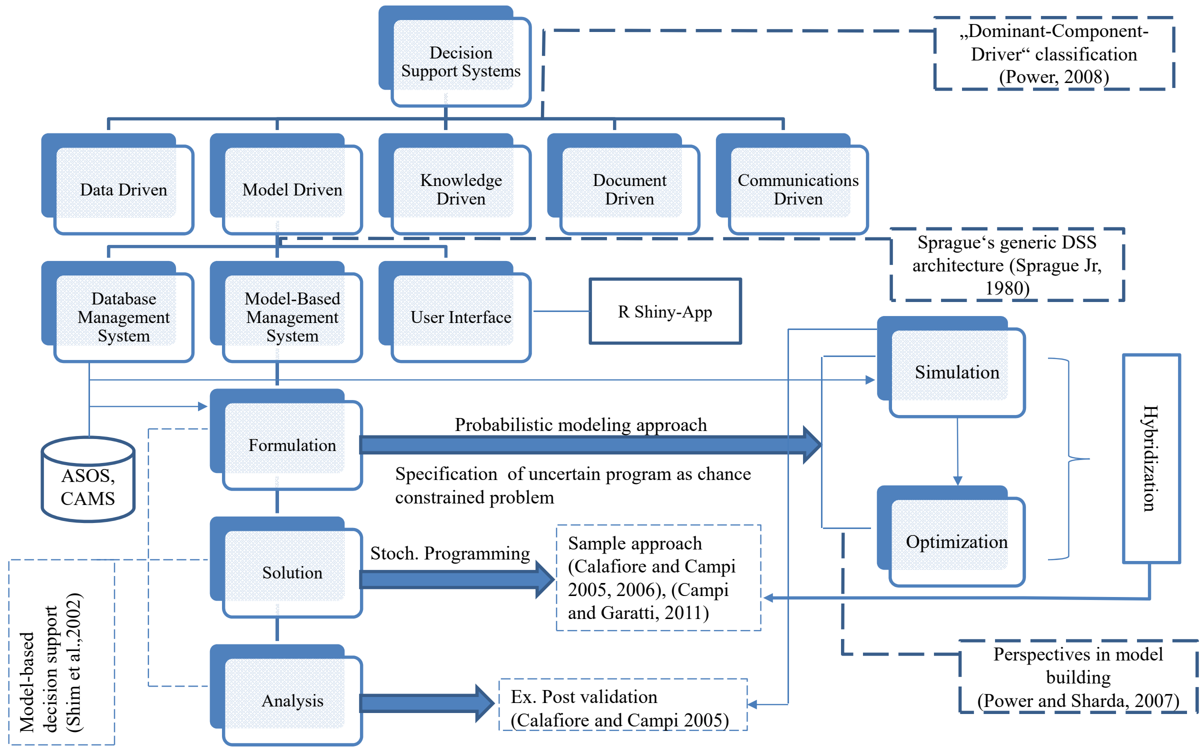
Robust solution via probabilistic constraints

Prob. Design

$$\min_{x \in X} f(x) \quad \text{s.t}$$
$$\Pr\left\{\sum_i x_i \tilde{P}_{it} \geq d_t\right\} \geq \chi$$

Variable	
x_i	Capacity of Wind and Solar power
X	Feasible set (restrictions)
P_{it}	Power per installed capacity from i-th technology at time t
f	Cost function
d_t	Demand
χ	Ex-ante specified level of reliability

Methodology



Methodology-Solution

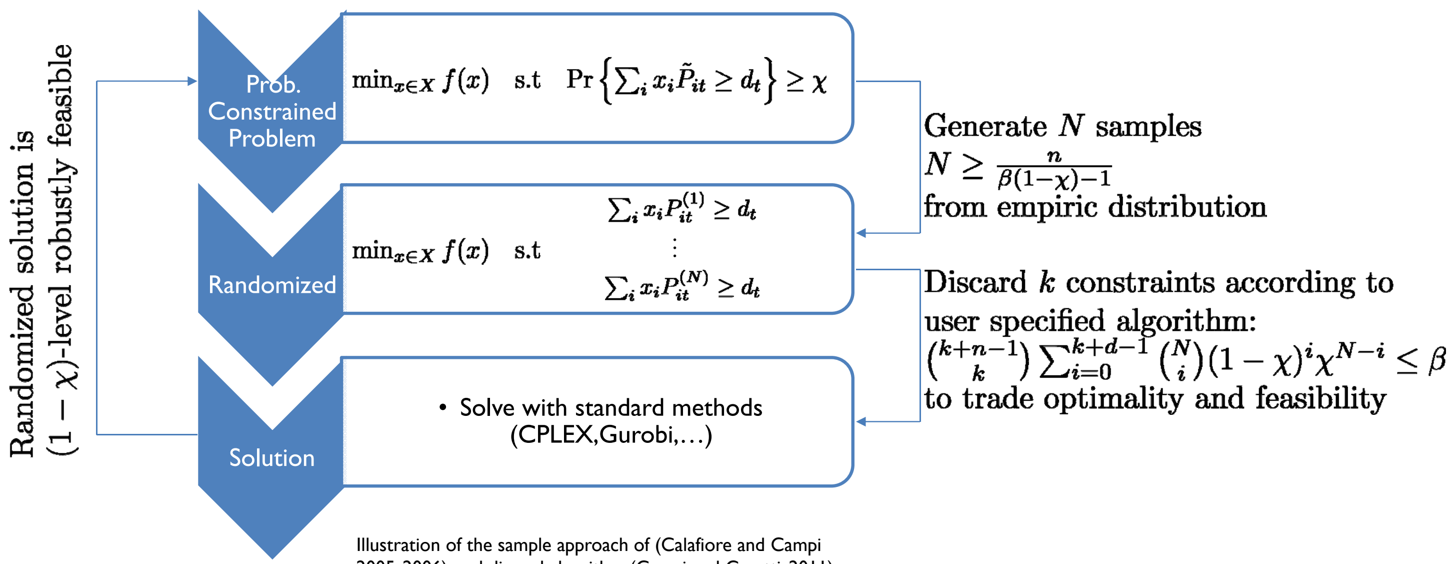
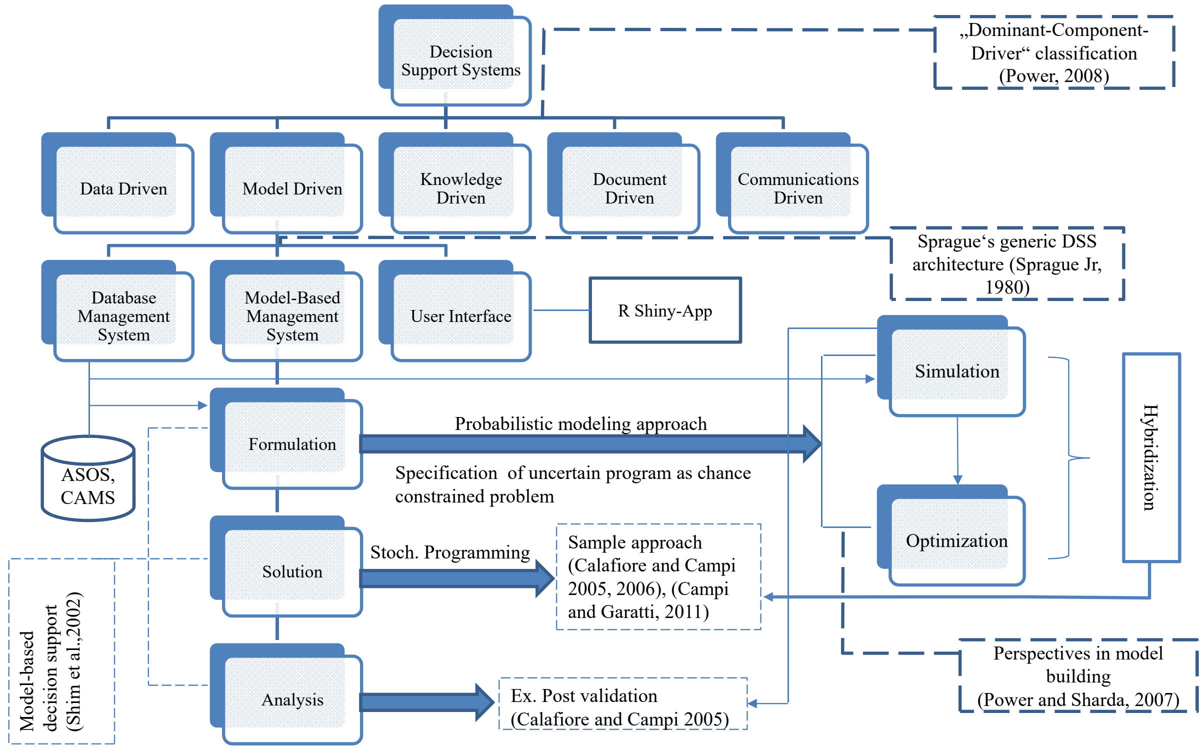
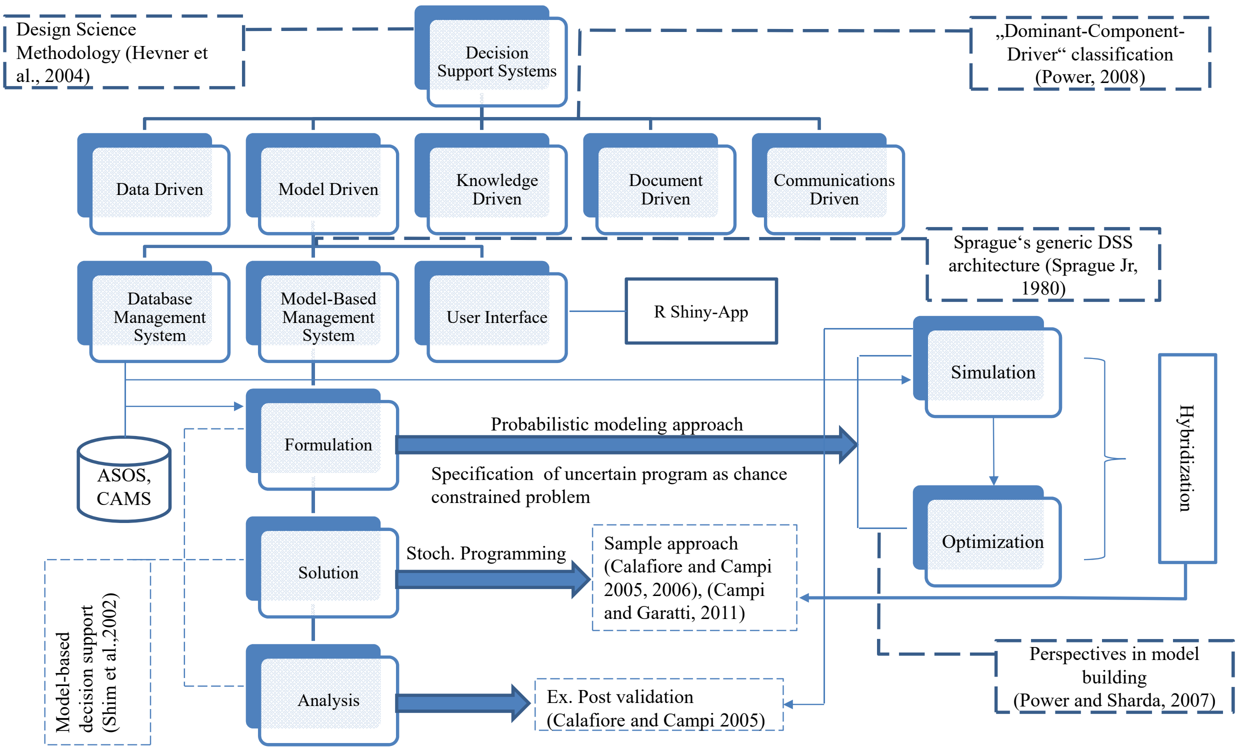


Illustration of the sample approach of (Calafiore and Campi 2005, 2006), and discard algorithm (Campi and Garatti, 2011)

Methodology

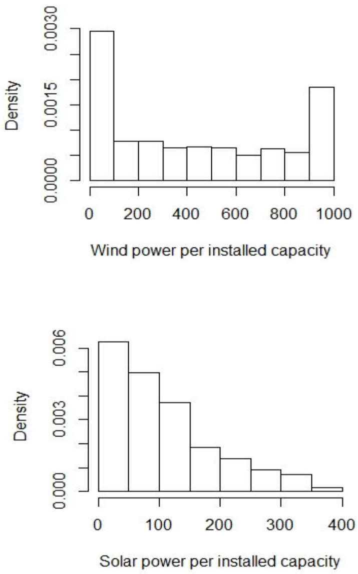


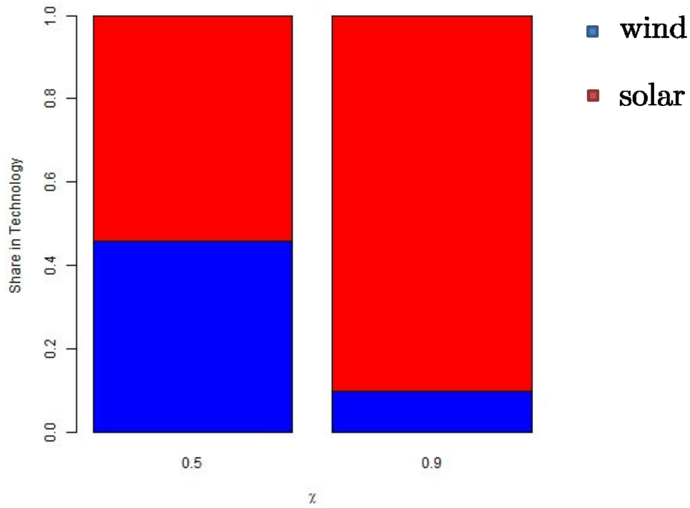
Methodology



Expected Results

- Solution of the capacity budgeting problem for wind and solar technology





Literature

Liu, M., Wu, F. F., and Ni, Y. (2006). A survey on risk management in electricity markets. In 2006 IEEE Power Engineering Society General Meeting, pages 6pp. IEEE.

Rezaeipour, R. and Zahedi, A. (2017). Multi-objective based economic operation and environmental performance of pv-based large industrial consumer. Solar energy, 157:227235.

Shaeezadeh, M., Akbarimajd, A., Ghadimi, N., and Madadkhani, M. (2019). Deterministic-Based Energy Procurement, pages 2545. Springer International Publishing, Cham.

Beraldi, P., Violi, A., Bruni, M. E., and Carrozzino, G. (2017). A probabilistically constrained approach for the energy procurement problem. Energies,10(12):2179.

Power, D. J. (2008). Decision support systems: a historical overview. In Handbook on decision support systems 1, pages121-140. Springer.

Hevner, A., March, S., Park, J., and Ram, S. (2004). Design science in information systems research. MIS Quarterly, 28(1).

Sprague Jr, R. H. (1980). A framework for the development of decision support systems. MIS quarterly, pages 1-26.

Power, D. J. and Sharda, R. (2007). Model-driven decision support systems: Concepts and research directions. Decision Support Systems, 43(3):1044-1061.

Shim, J. P., Warkentin, M., Courtney, J. F., Power, D. J., Sharda, R., and Carlsson, C. (2002). Past, present, and future of decision support technology. Decision support systems, 33(2):111-126.

Calaore, G. and Campi, M. C. (2005). Uncertain convex programs randomized solutions and confidence levels. Mathematical Programming, 102(1):25-46.

Calaore, G. C. and Campi, M. C. (2006). The scenario approach to robust control design. IEEE Transactions on Automatic Control, 51(5):742-753.

Campi, M. C. and Garatti, S. (2011). A sampling-and-discarding approach to chance-constrained optimization: feasibility and optimality. Journal of Optimization Theory and Applications, 148(2):257-280.