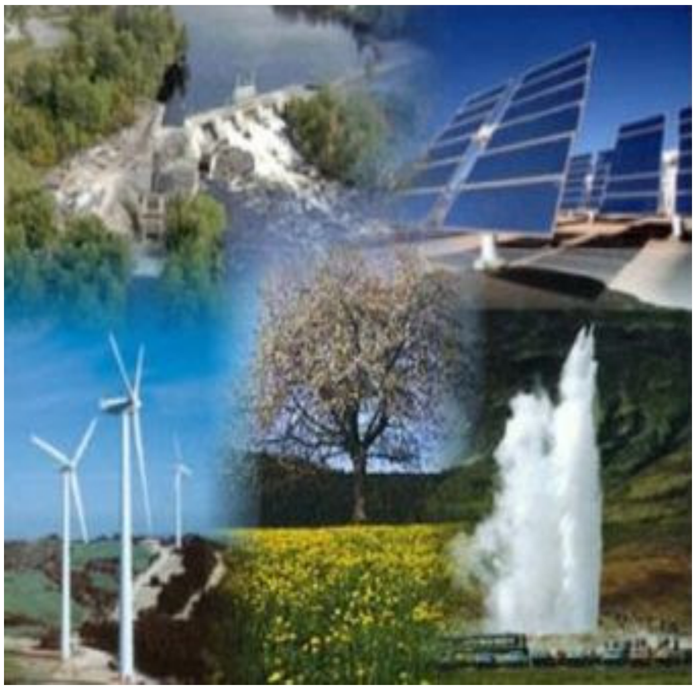
Paper No: 14PESGM0783

Effects of Wind Penetration in the Scheduling of a Hydro-Dominant Power System

Saulo R. Silva
Anderson Rodrigo de Queiroz
Luana M. Marangon Lima
José W. Marangon Lima

Federal University of Itajubá
arqueiroz@unifei.edu.br

Introduction



- **Renewable power** sources became a key aspect around the world by **disrupting old frontiers** in power systems
- These energy sources are linked to **sustainable development** that is one of the main goals of the modern society these days
- **The raise of wind power installed** capacity around the world constantly demand studies about its effects

Background

- The main problem with renewable power is its dependence on natural resources (**may not be available when necessary**)
- Hydropower is an exception of these restrictions, since **reservoirs can store water and control generation**
- Brazil presents a highly dominant renewable generation matrix (**mostly Hydro**)
- This work presents a model formulation for the **stochastic wind-hydrothermal scheduling problem** and we attempt to solve it using **SDDP**

Stochastic Wind-Hydrothermal Scheduling Problem

- **Wind power plants considered such as run-of-the river hydro**
- **Objective:** Minimize production costs of electricity to supply system electricity demand considering the operation of hydro, thermal and wind power generators
- **Constraints:**
  - Water balance
  - Electricity demand satisfaction
  - Max wind power generation
  - Electricity exchanges between regions
  - Other operational bounds

Model Formulation for Stage t

$$z = min \sum_{i \in I} \left[\sum_{k \in G_i} c_k^t g t_k^t + \rho^t u^t \right] + \mathbb{E}_{b_{t+1}} h_{t+1}(x^t, b_{t+1}^{\omega})$$

s.t. $$x_h^t = x_h^{t-1} + \tau b_{h,t}^{\omega} - vt_h^t + s_h^t + \sum_{m \in M_h} (vt_m^t + s_m^t)$$

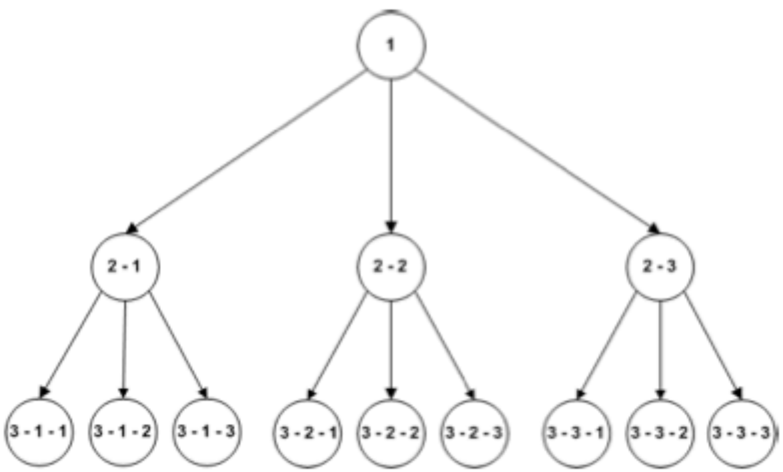
$$\sum_{h \epsilon H_i} \frac{\delta_h}{\tau} vt_h^t + \sum_{k \in G_i} gt_k^t + \sum_{v \in V_i} w_v^t + \sum_{j:(i,j) \in E} p_{i,j}^t - \sum_{j:(i,j) \in E} p_{j,i}^t + u^t = d_i^t$$

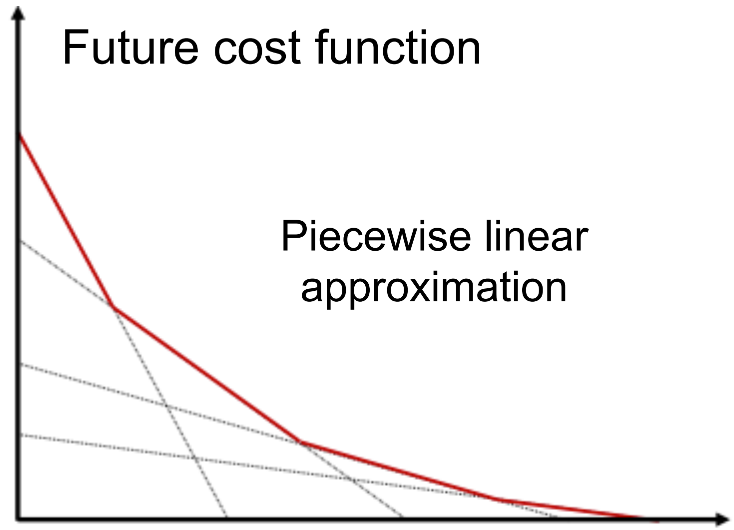
$$\sum_{i:(i,j) \in E} (p_{i,j}^t - p_{j,i}^t) = 0 \quad \forall j \in I$$

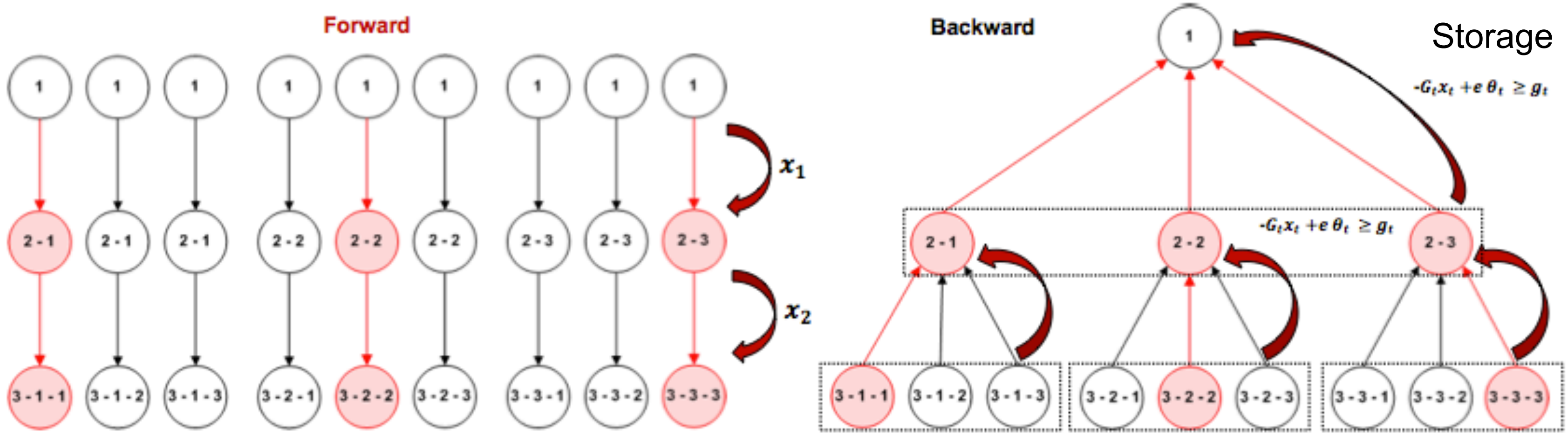
$$w_v^t \leq n \frac{1}{2} \sigma . A . w s_{v,t}^{\omega}{}^3 C_p^t \;\; \forall v \in V_i$$

Bounds

Sampling-based Decomposition

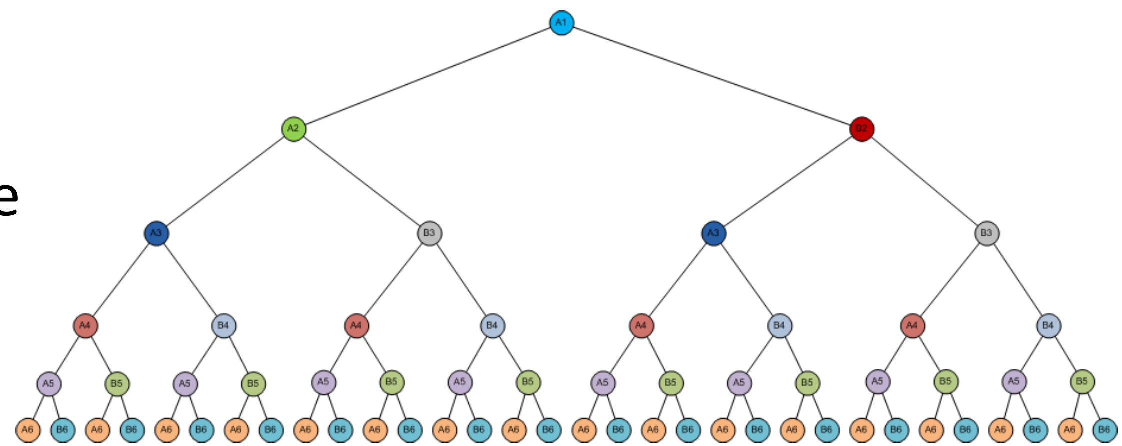






Wind Speed & Water Inflow Scenario Generation

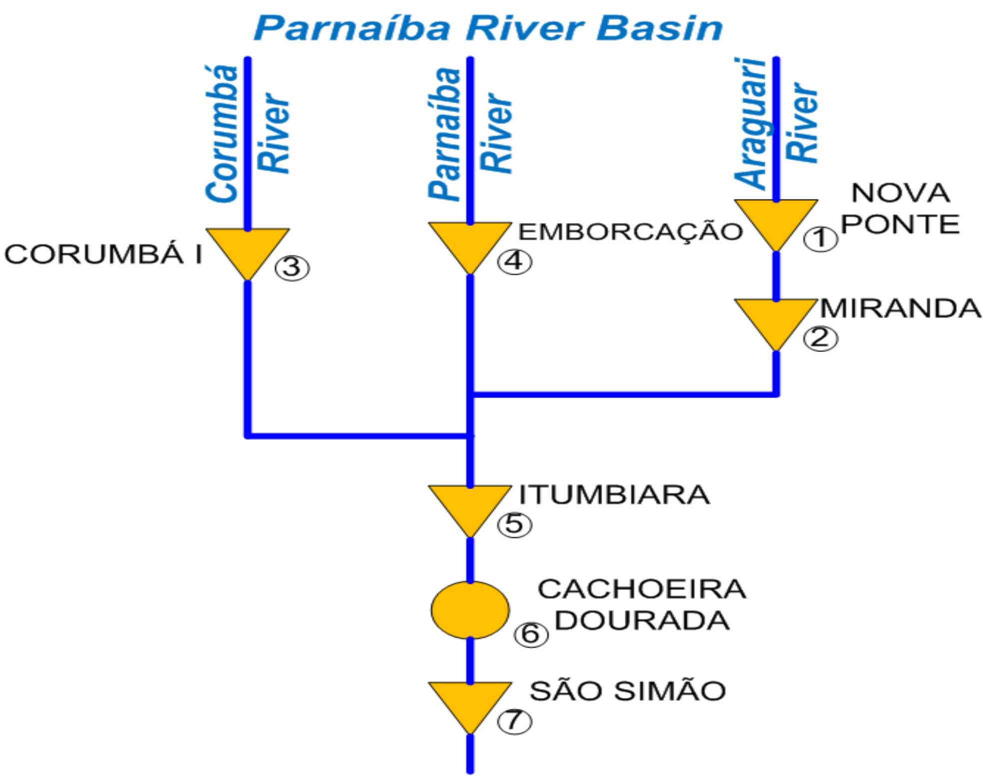
- We consider **water inflows and wind speed to be stochastic** and we sample from a probability distribution in order to construct a sample tree with different scenarios
- First stage problem the water inflows and wind speed are assumed to be deterministically known
- **Interstage independent** scenario tree

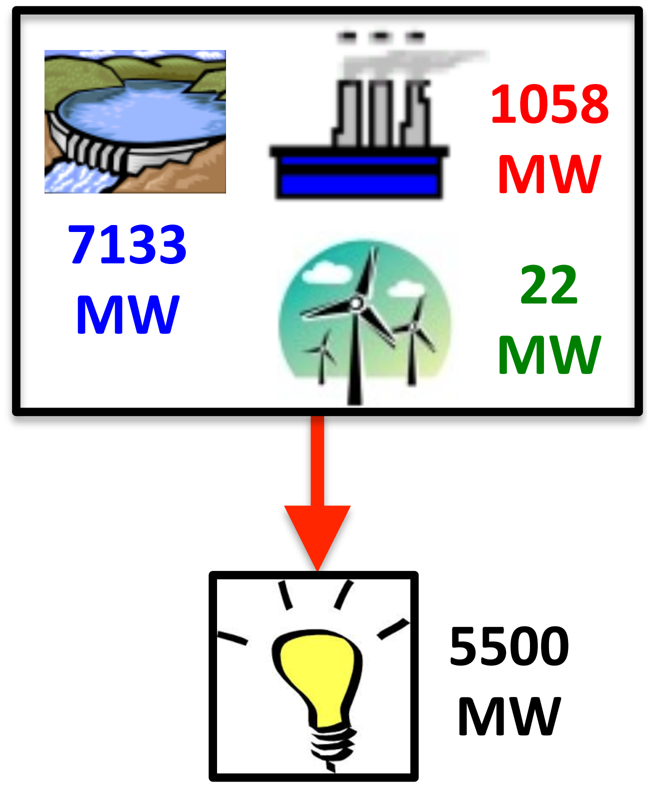


- Scenarios are drawn from **independent normal distributions** N[μ,σ2] and correlation is passed through **Cholesky decomposition**

Study Case

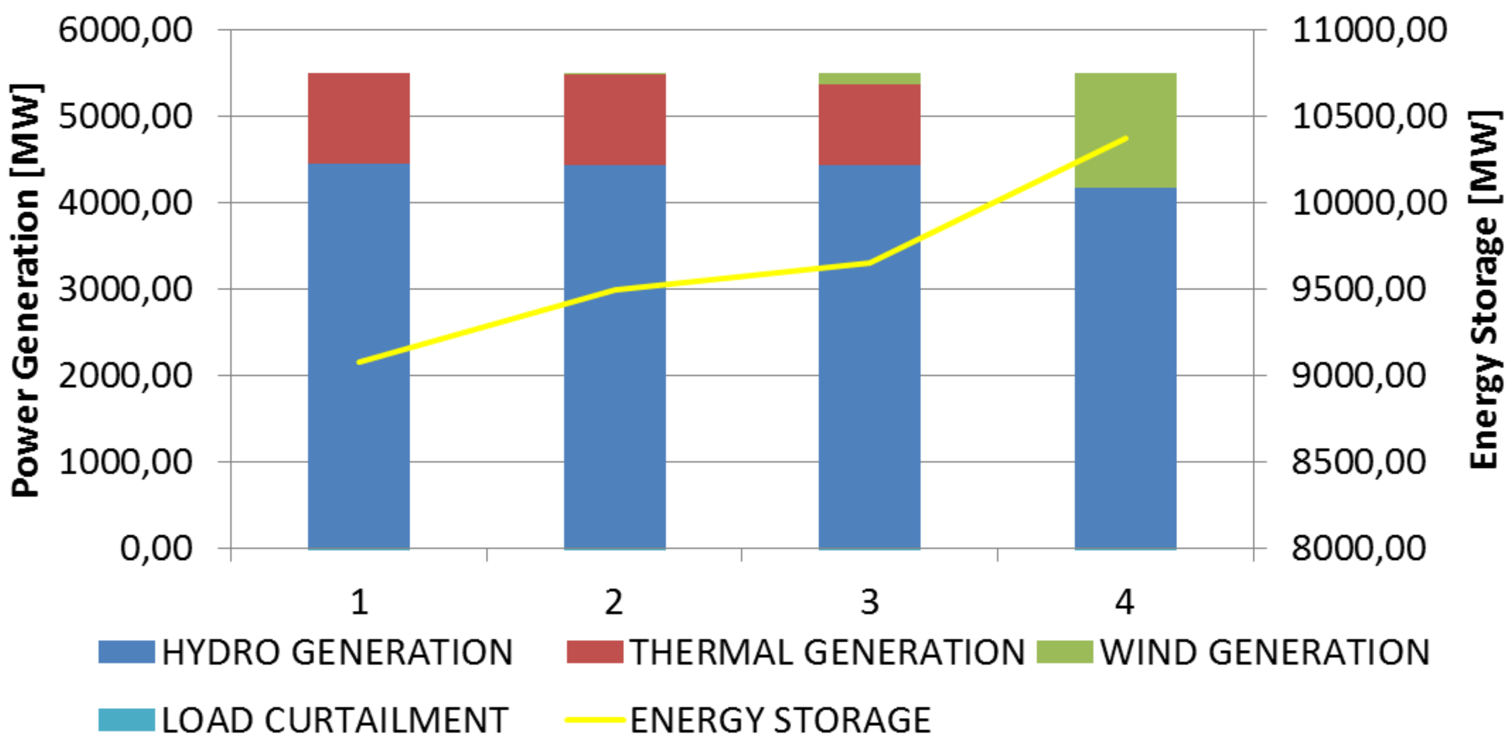
- Deterministic Wind X Stochastic Wind





Results

- **Deterministic** approach tends to **overestimate** wind generation
- **Complementarity Behavior Hydro-Wind**



Average Expected Costs

- Although the behavior in both situations is similar, the average wind power generation obtained in the stochastic case is smaller than the historical average

Wind Generation	Stochastic	Deterministic
None	$ 446,281.02	
1x	$ 404,797.17	$ 412,934.21
10x	$ 320.660,31	$ 376,306.90
100x	$ 6,680.58	$ 2,458.73

Conclusions & Future Work

- The impacts of the wind in the context of the power generation scheduling problem is relevant when installed capacity scales up → **better models**
- We have created a sampled scenario tree capable of representing stochastic and seasonal characteristics of wind and water inflows
- We aim to Improve our model:
  - **Interstage dependency** between time stages
  - Include **climate variables**

Thank you!!!

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