Introduction

Operations Research

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Stochastic Programming
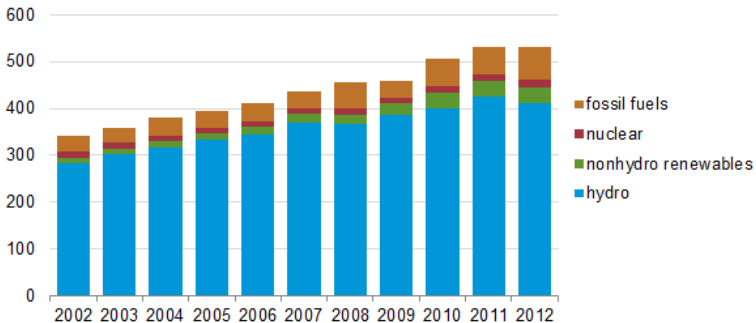
- Features: uncertainty, multiple time stages
- It is everywhere
  - Revenue management
  - Financial planning
  - Energy
  - Fleet assignment
  - and many more ...

Brazil's electricity generation by fuel type (2002-12)
billion kilowatthours

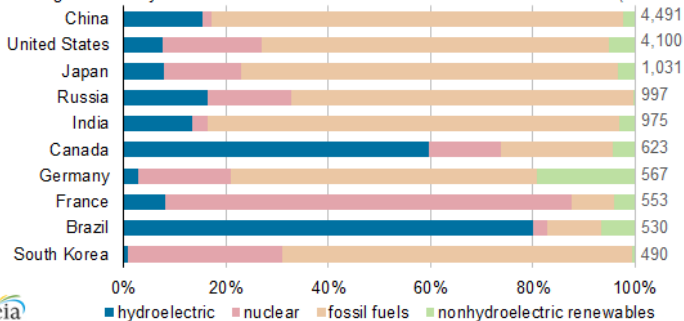Legend: fossil fuels, nuclear, nonhydro renewables, hydro

Source: U.S. Energy Information Administration, International Energy Statistics

Brazilian Energy Consumption
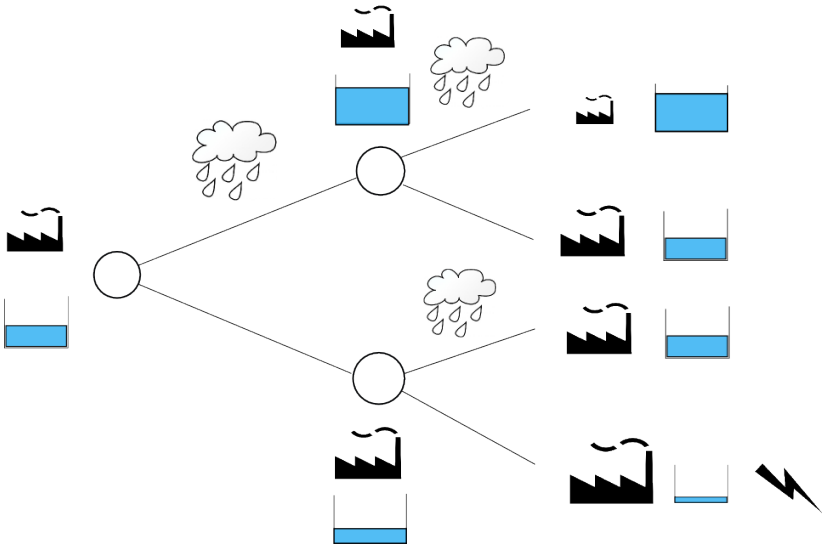

Top 10 electricity generating countries, 2011
total net generation by fuel source

total net generation
(billion kWh)

Country		total net generation (billion kWh)
China		4,491
United States		4,100
Japan		1,031
Russia		997
India		975
Canada		623
Germany		567
France		553
Brazil		530
South Korea		490

0%   20%   40%   60%   80%   100%

■ hydroelectric   ■ nuclear   ■ fossil fuels   ■ nonhydroelectric renewables

Source: U.S. Energy Information Administration, International Energy Statistics

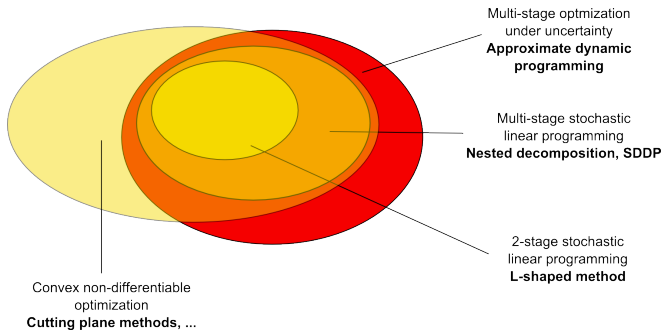# Stochastic Programming in Action: PSR Cloud
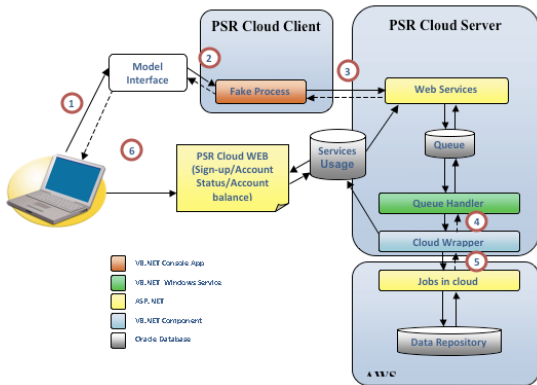
Stochastic dual dynamic programming is a parallel algorithm for hydrothermal scheduling that runs in Amazon cloud

Solving Stochastic Programs

- What can we solve?
  - We will focus (mostly) on **huge** linear programs
  - The instances do not fit in memory
- How can we solve them?
  - Decomposition methods
  - Parallel computing (but not in this class)
- Why solve them?
  - Does it make a difference?

Toolbox

The tools are applicable *beyond* stochastic programming:

- Cutting plane techniques
- Approximate dynamic programming

Multi-stage optmization
under uncertainty
**Approximate dynamic
programming**

Multi-stage stochastic
linear programming
Nested decomposition, SDDP

2-stage stochastic
linear programming
L-shaped method

Convex non-differentiable
optimization
Cutting plane methods, ...

Learning Outcomes

- **Formulate** problems of decision-making under uncertainty as mathematical programs
- **Identify** structure in large-scale mathematical programs that enables their decomposition
- **Design** algorithms for solving large-scale optimization problems under uncertainty
- **Implement** algorithms for solving large-scale optimization problems in a math programming language
- **Evaluate** the quality of policies for making decisions under uncertainty