Concepts and Practice Using Stochastic Programs for Determining Reserve Requirements

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Outline

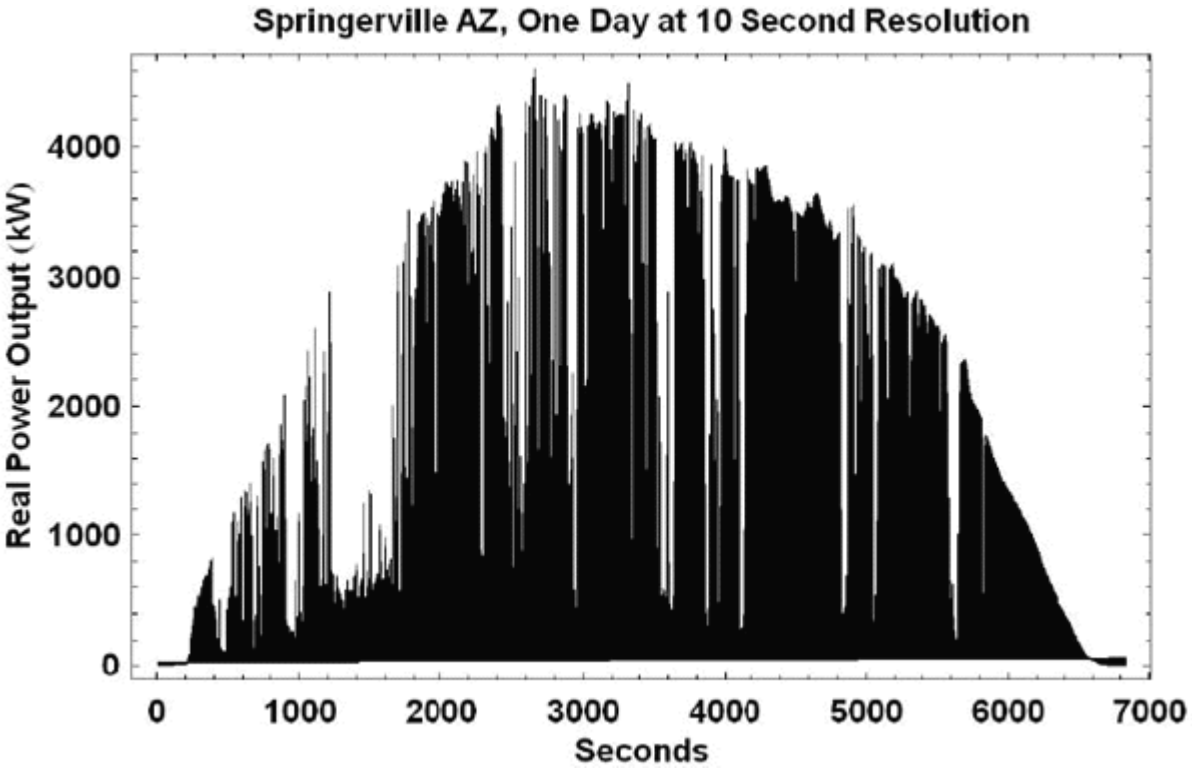
- Introduction
- Grid of the Future
  - What do we want?
  - How can we get there?
- Simple Energy & Reserve Dispatch Model
  - Purpose
  - Model Parameters
  - Experiment Results
  - Local Reserve Requirements
- Questions and Discussions

Introduction

- Renewable resources increasing worldwide
  - IEA: 80% of all new power generation in OECD [1]
  - Renewable Portfolio Standards (RPS)
  - Improvements in bulk economics
- Operational challenges
  - Uncertainty in forecasts
  - Intermittency
  - Inertia considerations

- [1] IEA, Medium-Term Renewable Energy Market Report, 2014

Introduction



- [2] J. Apt and A. Curtright, “The Spectrum of Power from Utility-Scale Wind Farms and Solar Photovoltaic Arrays,” Carnegie Mellon Electricity Industry Center, CEIC-08-04

Grid of the Future

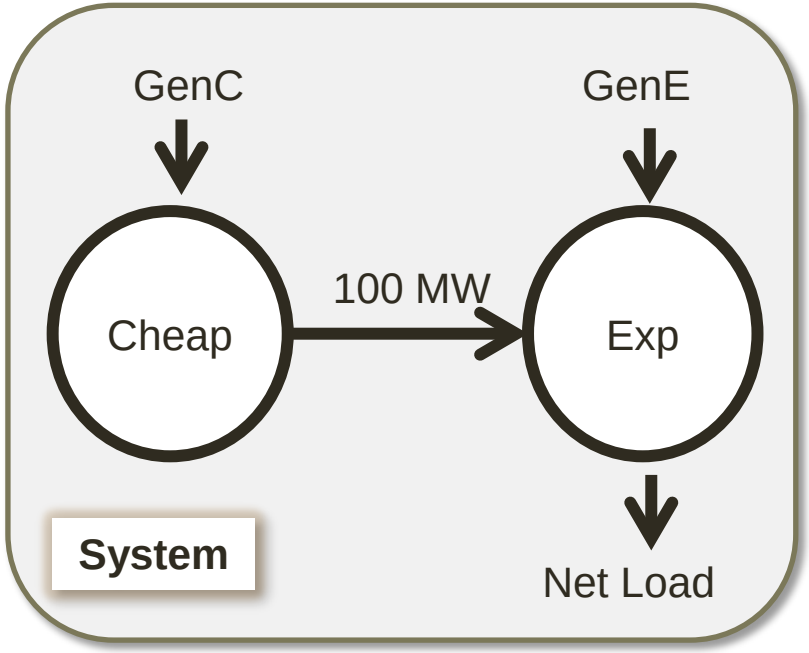
- What do we want?
  - Responsive
  - Flexible
  - Resilient
  - Economical
  - “Smart”
  - …
- Where are the opportunities for improvements soon?
  - Better location and quantity of reserves to manage uncertainty

Grid of the Future

- Gradual introduction of elements of stochastic optimization can be an effective way to aid in transitioning to the grid of the future
- However, computational properties can pose challenges
- Proper choice in operational cycle can naturally mitigate some issues
- At sub-hourly time frames…
  - Uncertainty in forecasts has greatly reduced
  - Some long-running units cannot change commitment
  - Some units cannot change dispatch set point

Simple Energy & Reserve Dispatch Model

- Transparent example to demonstrate characteristics
- Analyze procurement of reserves
- Demonstrate different policies for stage-wise decisions



Model Parameters

Generation

Name	Area	Maximum Dispatch	Minimum Dispatch	Energy Cost	Cold Start Cost
GenC	PGE_VLY	200 MW	ε MW	$10 /MWh	$(2ε)
GenE	SCE	50+ε MW	ε MW	$40 /MWh	$(3ε)

Net Load

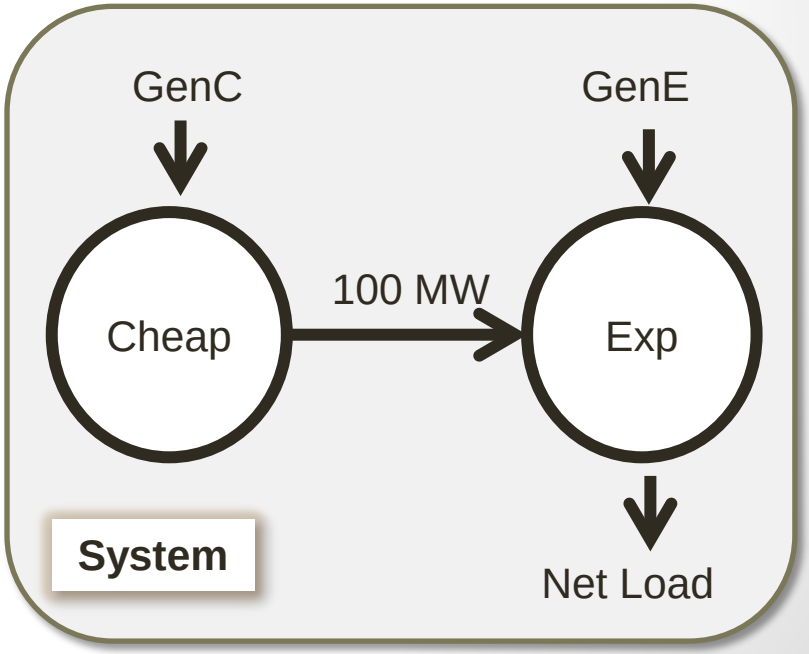
Scenario	Net Load
High	150 MW
Expected	100 MW
Low	50 MW

Sys Reserve

Model	LFU
Determ	50 MW
Stoch	0 MW

Network

Source	Sink	Capacity
Cheap	Expensive	100+ε MW
Expensive	Cheap	100+ε MW



Perfect Foresight Deterministic Results

Commitment Decisions	Settlement Decisions
• Unit On/Off • Reserve Schedule	• Energy Schedule • Reserve Schedule

	Reserve		Energy		
Scenario	**GenC**	**GenE**	**GenC**	**Flow →**	**GenE**
Low Net Load	50 MW	0 MW	50 MW	50 MW	0 MW
E{Net Load}	50 MW	0 MW	100 MW	100 MW	0 MW
High Net Load	50 MW	0 MW	100 MW	100 MW	50 MW

- Deterministic modeling foresees each Net Load scenario
  - Commitment decisions vary across scenarios
- Flow is from Cheap to Expensive
- GenE does not provide LFU reserve,
  because it is not committed in Low and Expected scenarios

Myopic Deterministic Results

Commitment Decisions	Settlement Decisions
• Unit On/Off • Reserve Schedule	• Energy Schedule • Reserve Schedule

	Reserve		Energy		
Scenario	**GenC**	**GenE**	**GenC**	**Flow →**	**GenE**
Low Net Load	50 MW	0 MW	50 MW	50 MW	0 MW
E{Net Load}	50 MW	0 MW	100 MW	100 MW	0 MW
High Net Load	50 MW	0 MW	100 MW	100 MW	0 MW

- Deterministic modeling foresees expected scenario
  - Commitment decisions do not vary across scenarios
- Flow is from Cheap to Expensive

High Net Load scenario has 50 MW energy violation

Stochastic Program Results

Commitment Decisions (AKA Stage 1)	Settlement Decisions (AKA Stage 2)
• Unit On/Off	• Energy Schedule

	Implicit Reserve		Energy		
Scenario	**GenC**	**GenE**	**GenC**	**Flow →**	**GenE**
Low Net Load	100 MW	50 MW	50 MW	50 MW	0 MW
E{Net Load}	100 MW	50 MW	100 MW	100 MW	0 MW
High Net Load	100 MW	50 MW	100 MW	100 MW	50 MW

- Off-line analysis… No actual commitment or settlement
- Both units have 50 MW implicit reserve… *Ambiguous need*
- Flow is from Cheap to Expensive
- Stochastic modeling has foresight for commitment decisions
  - High Net Load scenario is feasible, because GenE is On

LFU may be procured in either location… or none

Stochastic Program Results

Accounting "Reserve Need"

Define Reserve Need as "Maximum upward change in Energy across scenarios relative to Reference Scenario"

Commitment Decisions (AKA Stage 1)	Settlement Decisions (AKA Stage 2)
• Unit On/Off • Reserve Need	• Energy Schedule

	Reserve Need wrt E{}		Energy		
Scenario	**GenC**	**GenE**	**GenC**	**Flow →**	**GenE**
Low Net Load	0 MW	50 MW	50 MW	50 MW	0 MW
E{Net Load}	0 MW	50 MW	100 MW	100 MW	0 MW
High Net Load	0 MW	50 MW	100 MW	100 MW	50 MW

- Reserve Need is 50 MW

How much reserve is really needed from GenE?

Stochastic Program Results

Accounting "Reserve Need"

Assume reserve is not available (N/A) at GenE

Commitment Decisions (AKA Stage 1)	Settlement Decisions (AKA Stage 2)
• Unit On/Off • Reserve Need	• Energy Schedule

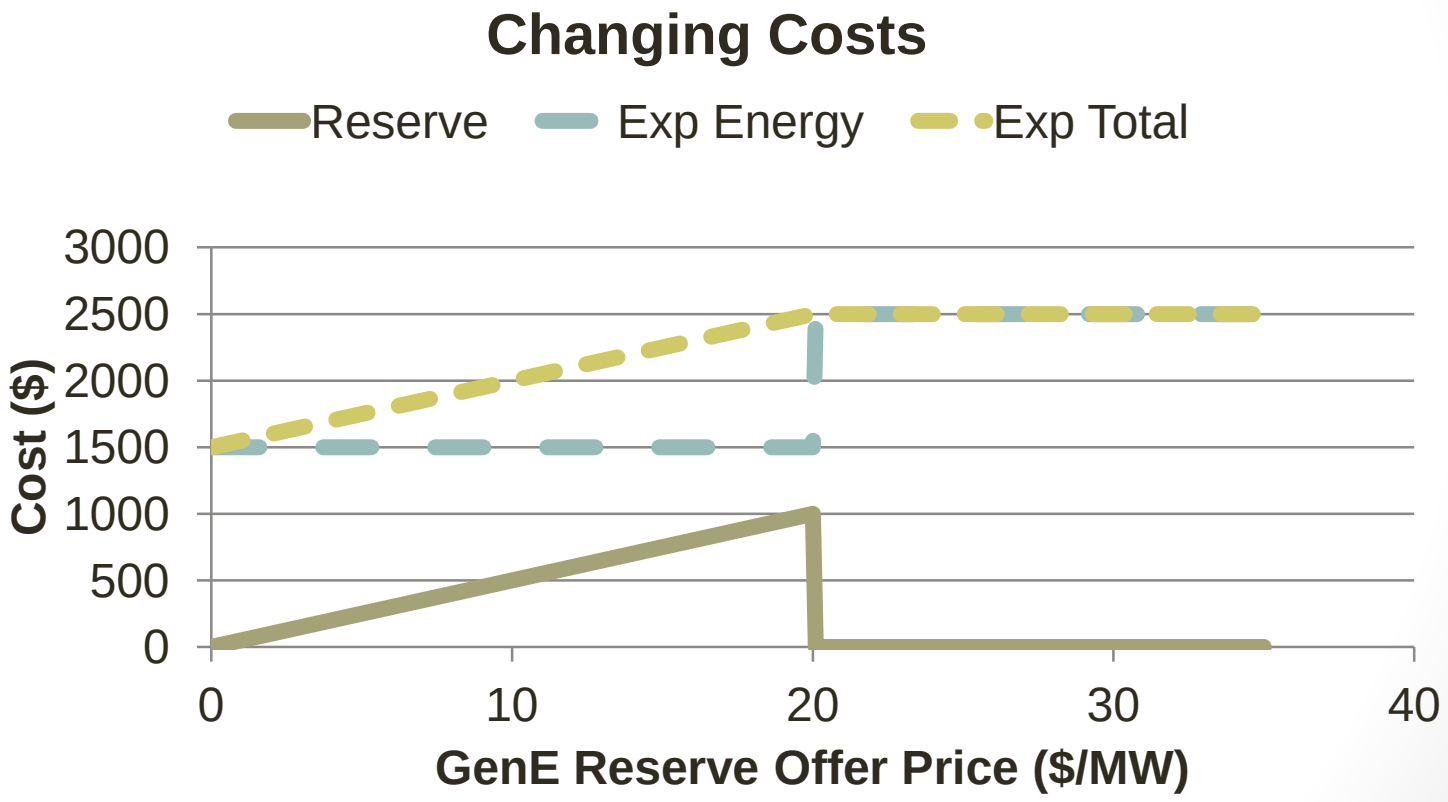
	Reserve Need wrt E{}		Energy		
Scenario	**GenC**	**GenE**	**GenC**	**Flow →**	**GenE**
Low Net Load	50 MW	N/A	0 MW	0 MW	50 MW
E{Net Load}	50 MW	N/A	50 MW	50 MW	50 MW
High Net Load	50 MW	N/A	100 MW	100 MW	50 MW

- Reserve Need is 50 MW
  - GenE does not really need to provide reserve!

How can we define reserve need?

Local Reserve Requirement

- Raise cost of Gen E reserve



Conclusions

- Myopia can lead to unplanned consequences
- Stochastic programs foresee and plan for alternatives
- Two treatments for Reserve
  - Implicit – Maximum upward change in Energy relative to current operating schedule
  - Explicit – Maximum upward change in Energy across scenarios relative to Reference Scenario
- Sufficient local reserve?
  - Yes, but economically determined
  - Requires unit commitment with foresight

Questions & Discussion