Preliminary Assumptions for Natural Gas Peaking Technologies (Revisited)

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At the last meeting…

- Revisited reference plant configurations
- Discussed updated preliminary capital cost and O&M estimates
- Introduced preliminary levelized cost estimates

Today's Discussion

- Revisit capital cost and O&M estimates for gas peakers (no changes from last meeting)
  - Frame, Aeroderivative, Intercooled
  - Recip
- Discuss capacity factors
  - Actual generation data from PNW
- Discuss updated levelized cost estimates
  - Frame, Aeroderivative, Intercooled, Recip

All Gas Peakers

REFERENCE PLANT

Proposed Configuration for Draft 7th Plan Reference Plants

Technology	Proposed Configuration	Capacity	Heat Rate (HHV)
Frame GT	(1) 215.8 MW GE 7F 5-series	~ 216 MW	9801
Aeroderivative GT	(4) 47.3 MW GE LM 6000PF Sprint	~ 190MW	9048
Intercooled/Aero Hybrid GT	(2) 100 MW GE LMS100 PB	200 MW	8541
Reciprocating Engine	(12) 18 MW Wärtsilä	220 MW	8370

Proposing reference plants that resemble capacity of Port Westward II (220MW) – most recent peaking plant to be constructed in the PNW

Preliminary Reference Plant – All Gas Peakers

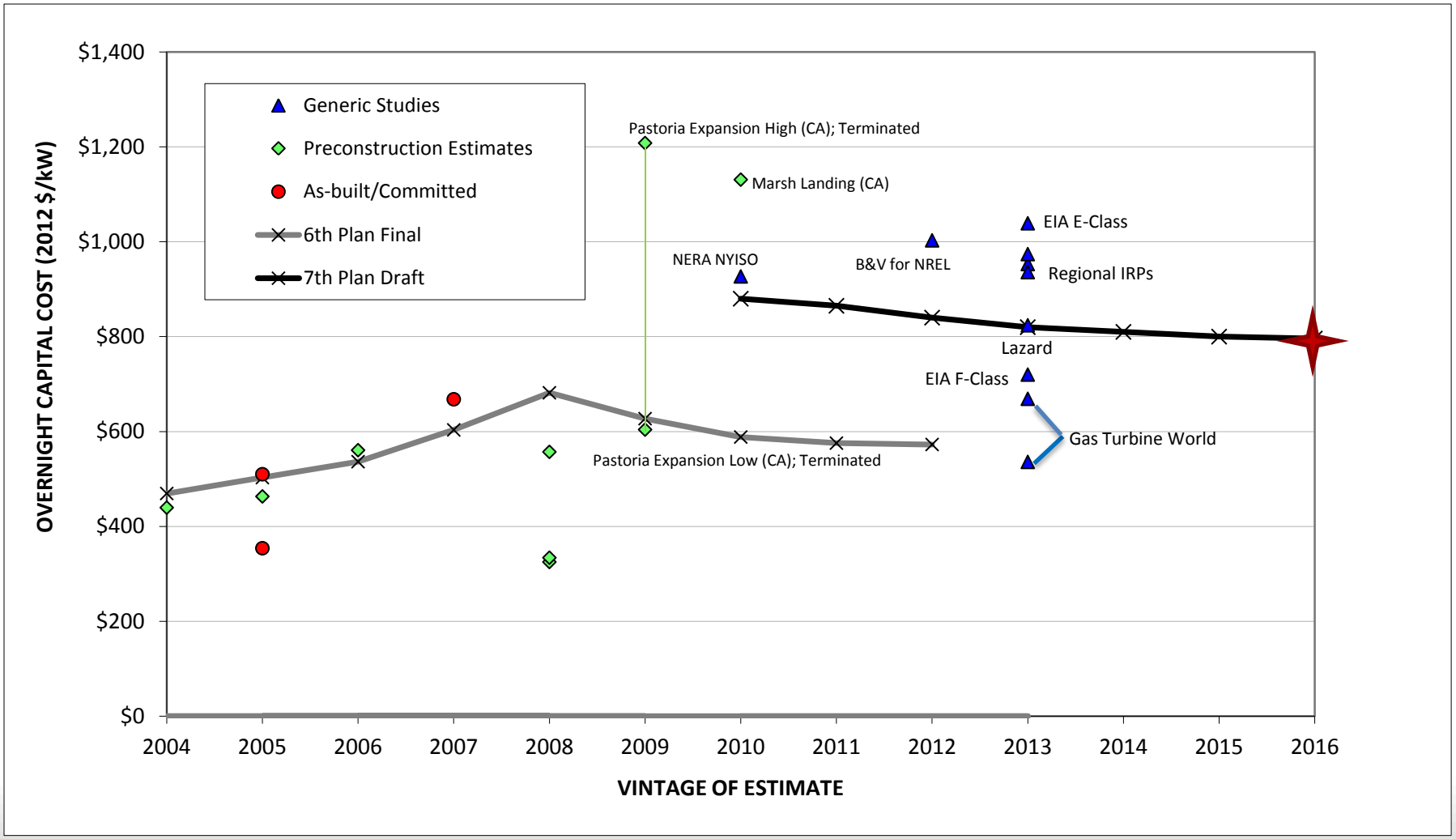
Year Dollars	2012 $

Capacity Factor	25%
Capital Cost Escalation	-0.5%
Economic Life (Years)	30
Construction Lead Time (Months)	18 planning & development 15 construction (33 months total, ~2.75 years)

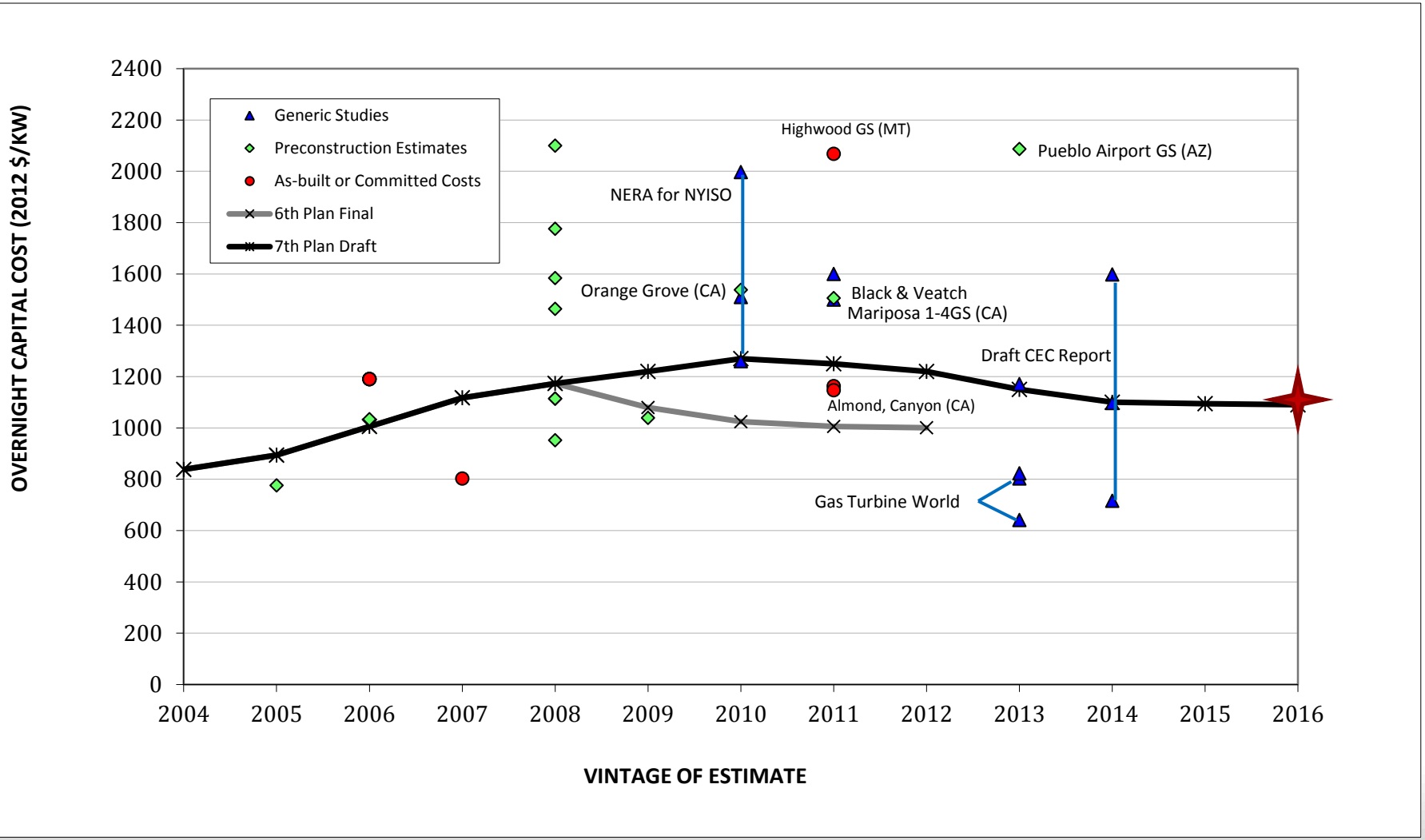
Capital and O&M

COST ASSUMPTIONS FOR GAS SINGLE CYCLE

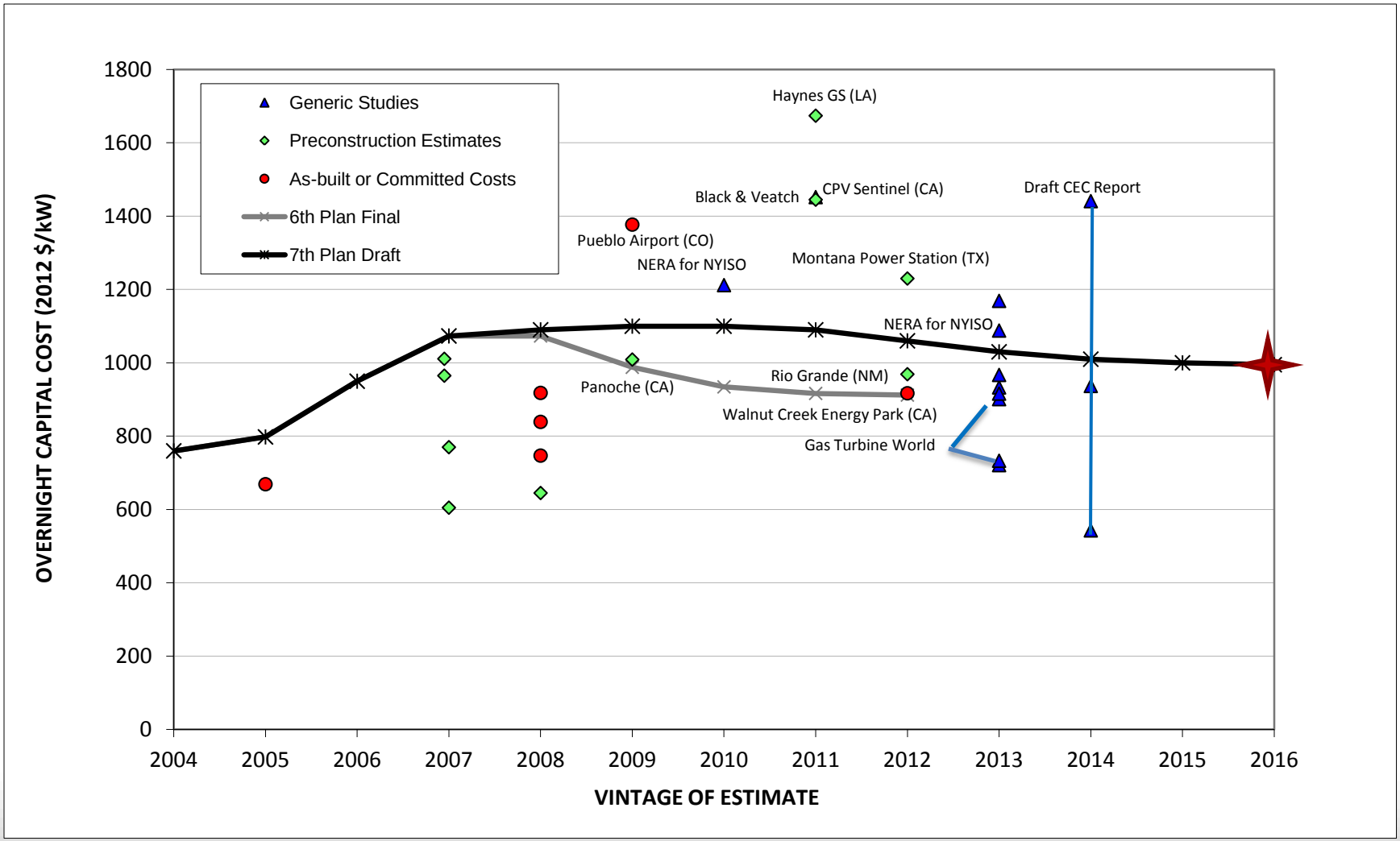
Preliminary Draft 7P Capital Cost Estimate for Frame GT



Preliminary Draft 7P Capital Cost Estimate for Aeroderivative GT



Preliminary Draft 7P Capital Cost Estimate for Intercooled GT



Capital and O&M

INFO AND COST ASSUMPTIONS FOR RECIPROCATING ENGINES

Reciprocating Engines

1. Recap
2. Capital and O&M Cost Estimate
3. Levelized Cost of Energy
4. Reference Plant

Reciprocating Engines (Recip)

- Recips are internal combustion engines – an air/fuel mix is compressed by a piston and ignited within a cylinder to drive a piston and turn the shaft
- Recips can burn a variety of fuels including natural gas, fuel oil, and biofuels
- Small individual engines are grouped into blocks called generating sets

Strengths

1. Excellent for flexibility: start quickly and follow load well, and have good part-load efficiencies
2. Maintain output at increasing elevations
3. Reliable and minimal water usage
4. Multiple engines – maintenance can be done without shutting down entire plant

Recips in the News

Wärtsilä has announced several new power plant projects – all revolving around renewable development

1. 3 50SG engines – 56MW - in Oklahoma, for wind balancing
2. 12 34SG engines – 112MW – in North Dakota to help power the oil drilling boom
3. 6 34DF engines – 50MW – in Hawaii to balance solar power production

1-Reciprocating Engine Capital Cost and O&M Estimate

- Capital cost estimates gathered from various recip. projects and evaluation reports
- Estimates were normalized to 2012 year dollars, lifecycle degrade, and regional cost (labor index)
- Capital Estimate:

  1,300 $/kW 2012$

- Fixed and Variable O&M cost estimates from two primary sources:
  - NERA 2013 Study for NYISO
  - PGE Port Westward 2 rate filing
- O&M Estimate

  Fixed:**10 $/kW-yr 2012$**

  Variable: **9 $/MWh 2012$**

Normalized Capital Costs for Reciprocating Engine Technologies

Normalized to NW region and 2012 real dollars

Summary of Cost Estimates

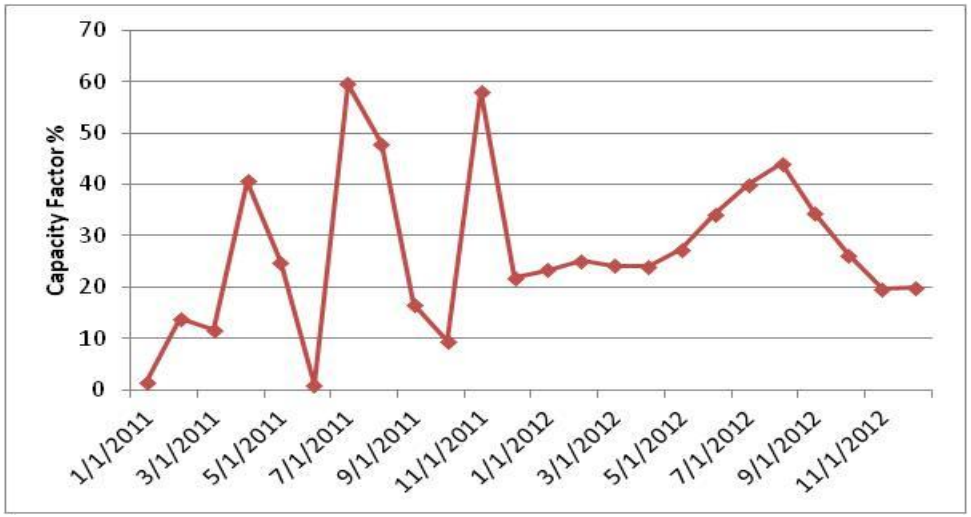
	Frame	Aero	Intercooled	Recip
Capital Cost (lifecycle)	$161.6 MM	$198 MM	$187 MM	$286 MM
Capital Cost (lifecycle) ($/kw)	$800	$1,100	$1,000	$1,300
Fixed O&M ($/kw-yr)	$7.00	$25.00	$11.00	$10.00
Variable O&M ($/MWh)	$10.00	$5.00	$7.00	$9.00

Discussion

CAPACITY FACTORS

Dave Gates Generating Station

Designed to provide regulation service to **balance generation and load on a moment-to-moment** basis and to provide regulation for **integration of renewables**.



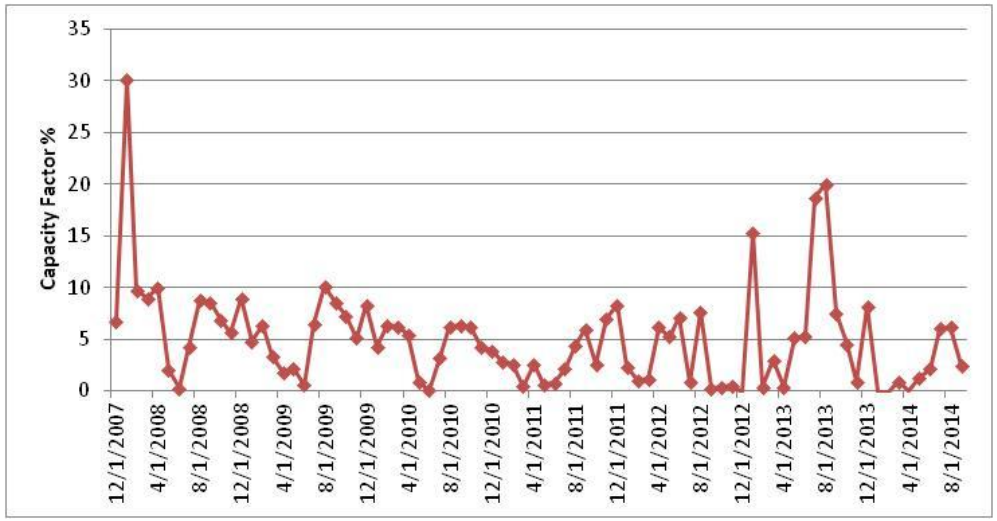
Duration	Capacity Factor
2013 Annual Average	35.3 %
2012 Annual Average	28.5 %
2011 Annual Average (Feb – Dec)	27.8 %

Capacity	**150 MW**
Location	Deer Lodge, MT
Technology	(3) 50 MW Pratt & Whitney SWIFTPAC
Service Date	January 2011

Photo credit: PowerMag.com

Danskin CT1 (Evander Anders Complex)

Constructed to help Idaho Power have adequate generating resources to meet present and future energy needs. – from Idaho Power's website



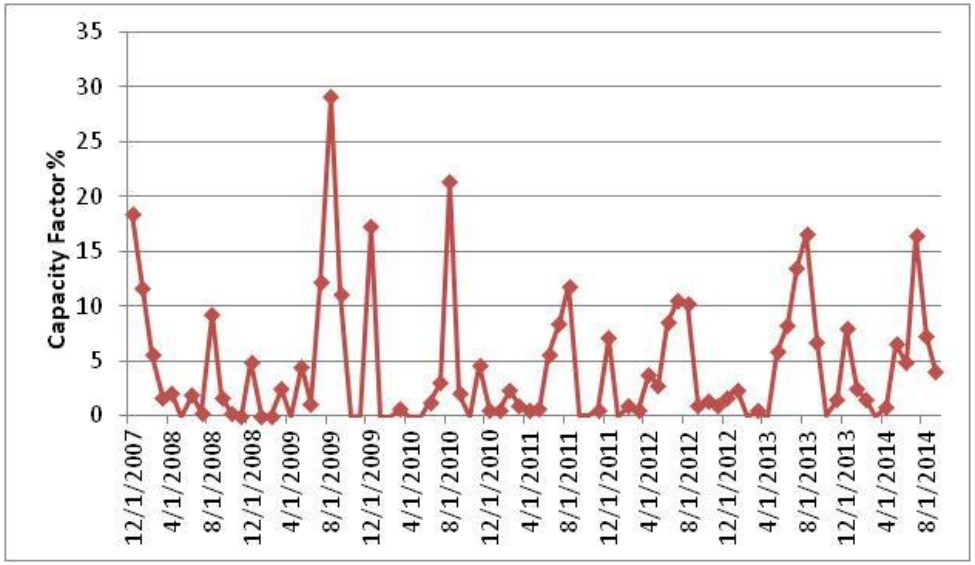
Duration	Capacity Factor
2013 Annual Average	7.5 %
2012 Annual Average	2.7 %
2011 Annual Average	3.4 %
2010 Annual Average	4.5 %
2009 Annual Average	5.4 %
2008 Annual Average	8.7 %

Capacity	**171 MW / 261 MW plant total**
Location	Mountain Home, ID
Technology	(1) 170 MW Siemens-Westinghouse SGT6-5000F
Service Date	June 2008 / Sep 2001

Photo credit: Tim Bondy

Bennett Mountain

Both the Danskin and Bennett Mountain plants are "peaking" generating resources, for use primarily in meeting short-duration demands for electricity during hot summer afternoons when air conditioning and irrigation loads reach their highest point. – from Idaho Power's website



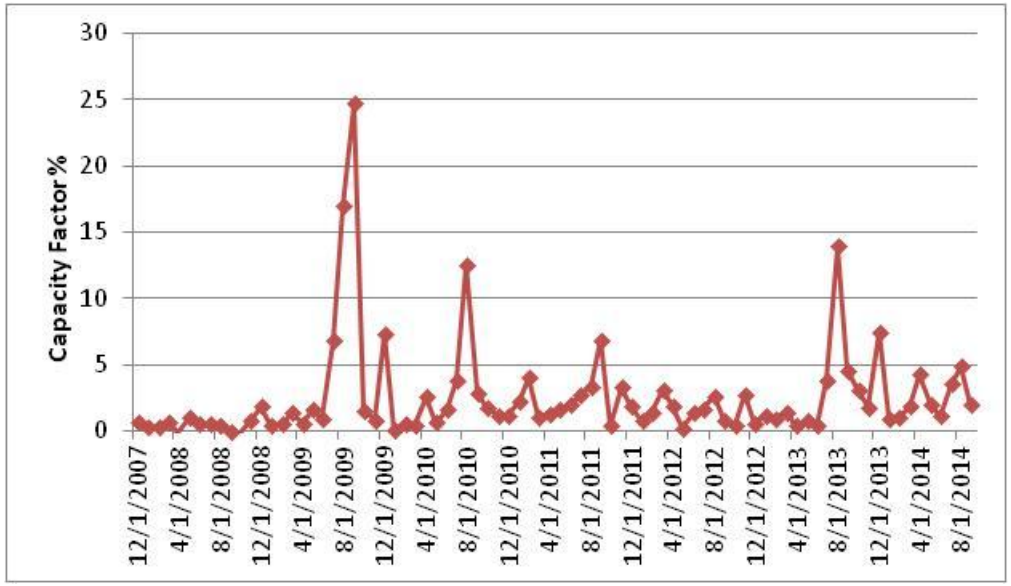
Duration	Capacity Factor
2013 Annual Average	5.3 %
2012 Annual Average	3.5 %
2011 Annual Average	3.2 %
2010 Annual Average	2.8 %
2009 Annual Average	6.5 %
2008 Annual Average	3.3 %

Capacity	**164 MW**
Location	Elmore, ID
Technology	(1) 164 MW Siemens-Westinghouse W501FD3
Service Date	April 2005

Photo credit: industcards.com

Fredonia 3 & 4

PSE employs the Fredonia facility primarily to provide back-up "peaking" energy for the utility's power system during daily or seasonal spikes in customers' power usage. – from Puget Sound Energy's website



Duration	Capacity Factor
2013 Annual Average	3.3 %
2012 Annual Average	1.5 %
2011 Annual Average	2.6 %
2010 Annual Average	2.4 %
2009 Annual Average	5.3 %
2008 Annual Average	0.5 %

Capacity	**108 MW / 314 MW total plant**
Location	Skagit Cty, WA
Technology	(2) 54 MW Pratt & Whitney FT8 Twin-pac
Service Date	July 2001 / May 1984

Photo credit: PSE.com

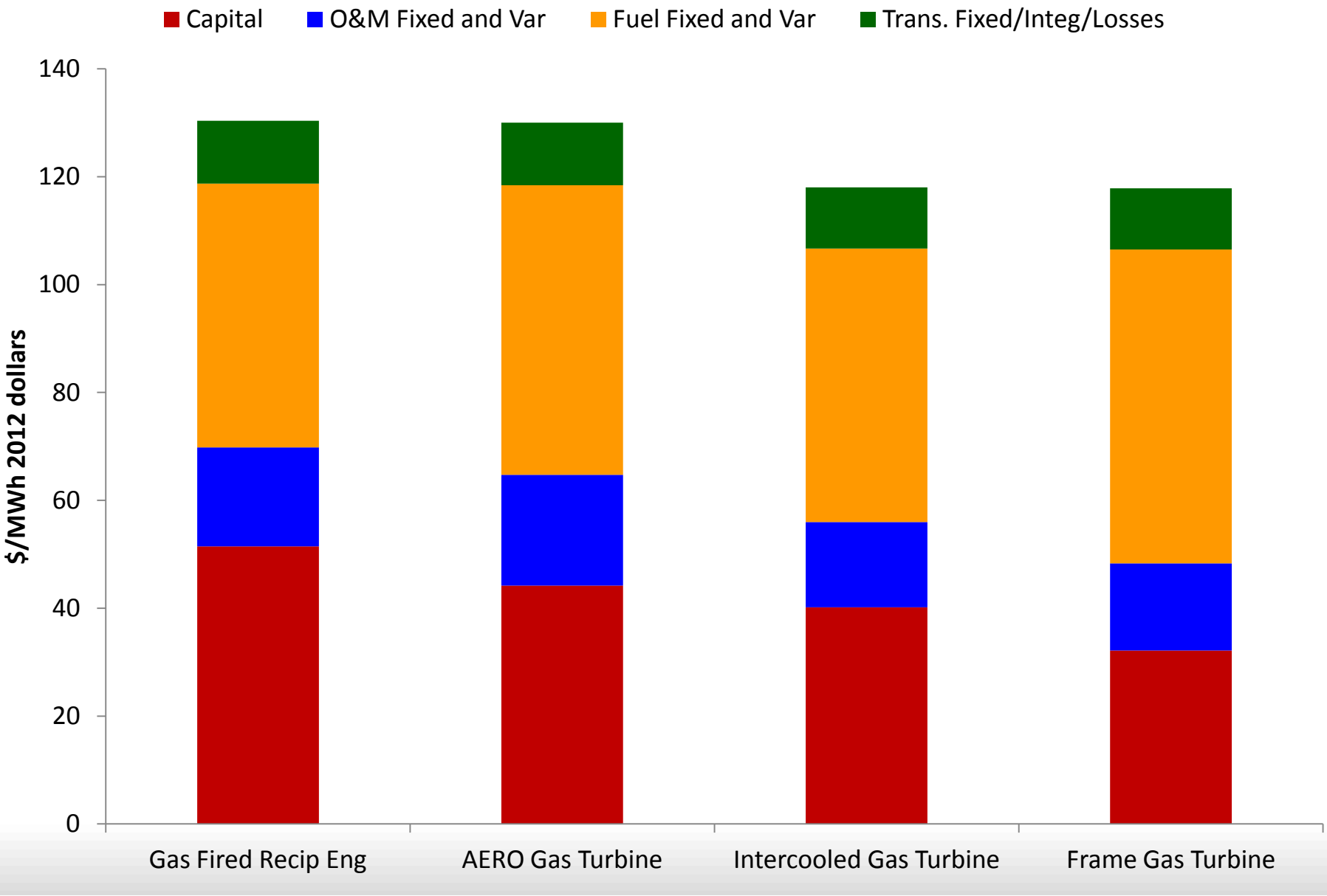
Representative Capacity Factor(s) for Comparative Levelized Cost Estimates

- Actual generation of peakers in past several years has averaged around 5-7% (with exception of Dave Gates GS)
- PGE anticipates 40% CF for PWII
- **For comparison purposes only (not a direct input into the Draft Seventh Plan or RPM)** – using a 25% CF as representative of future new gas peakers
  - Can also model levelized cost at various CFs (i.e. 10% and 40%)

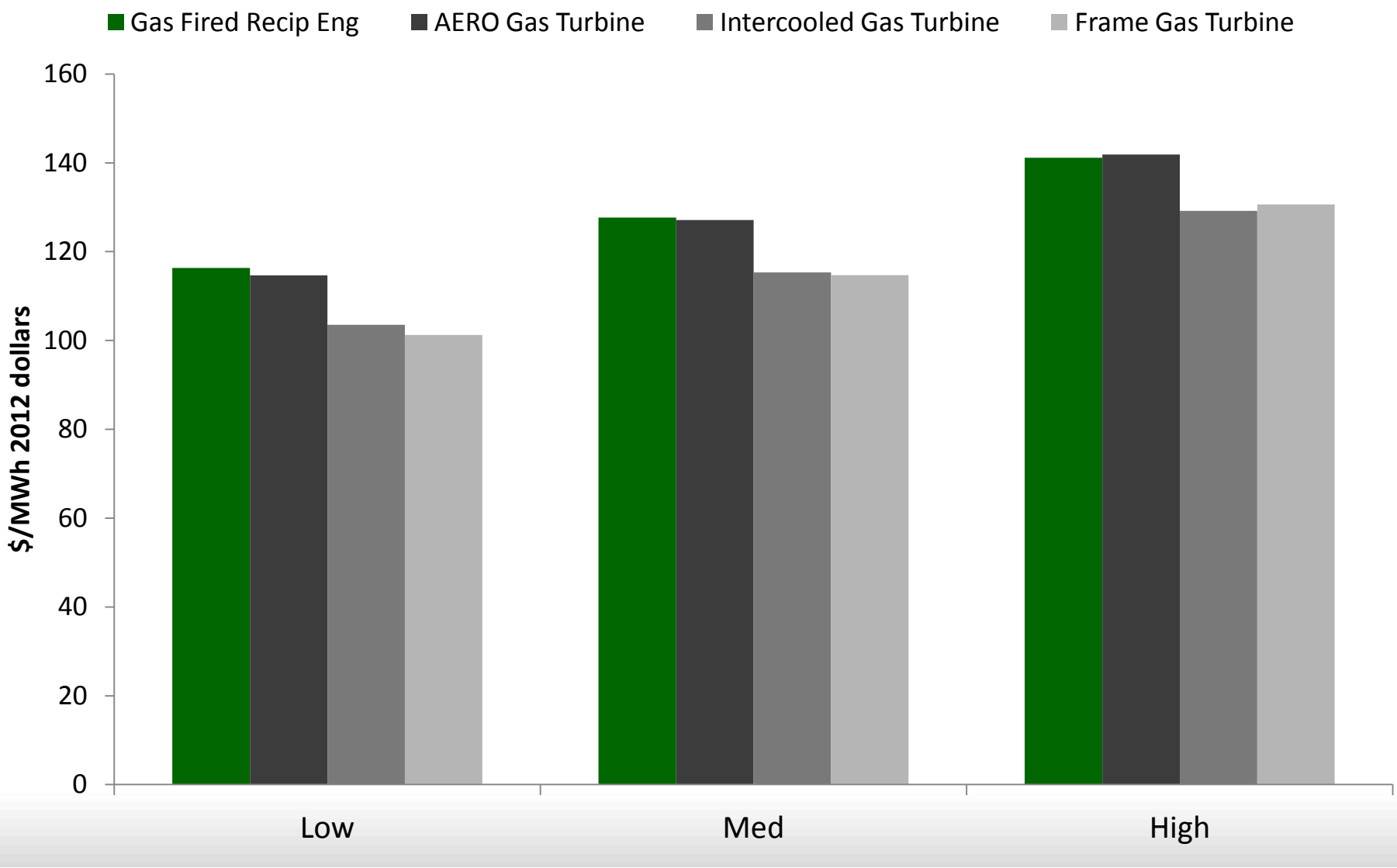
Levelized

COST ASSUMPTIONS

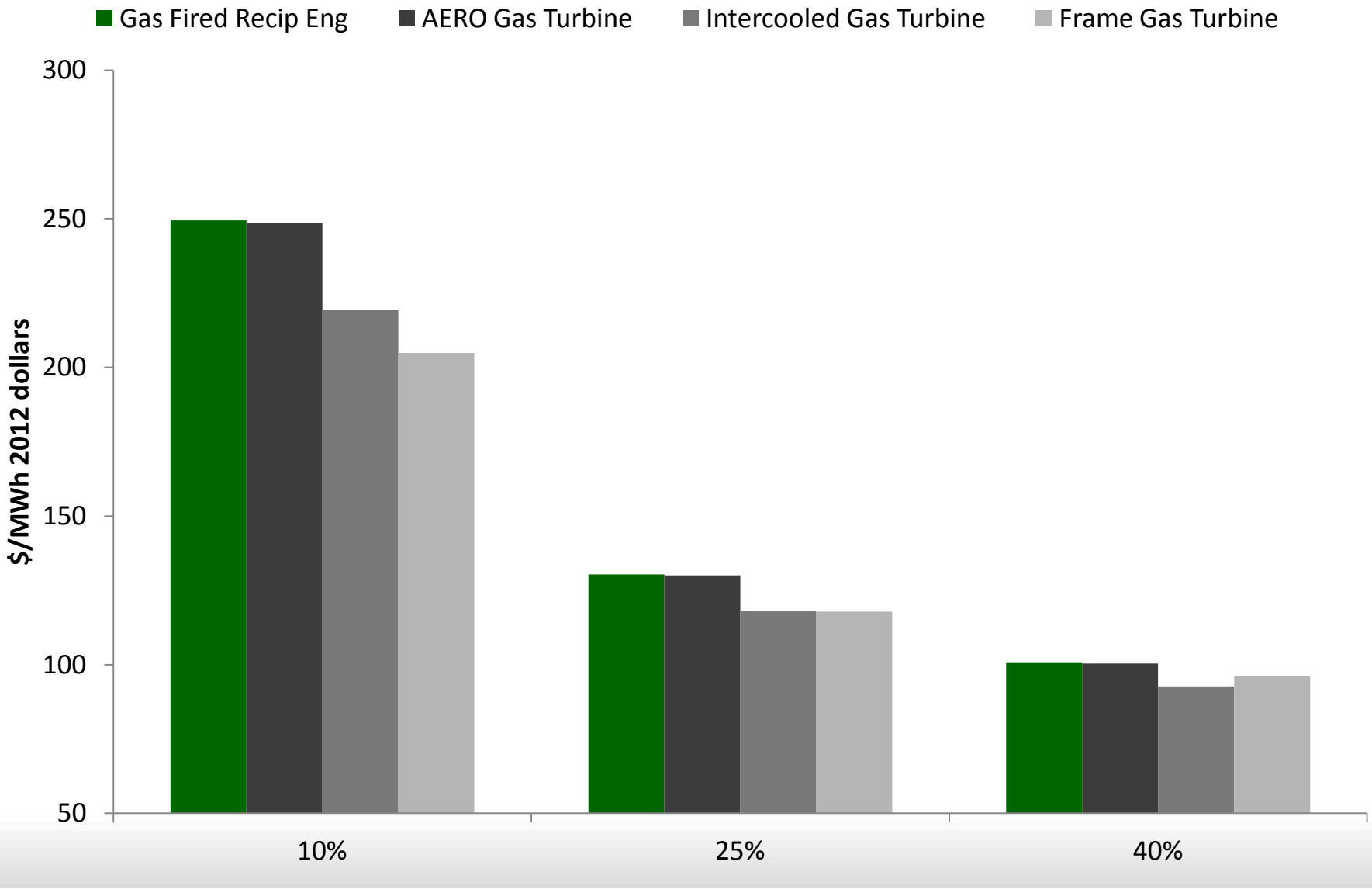
Gas Peakers - Levelized Cost of Energy (Cap Factor 25%)



Levelized Cost of Energy - Gas Fired Peaking Technologies by Gas Price Forecast (Cap. Factor 25%)



Levelized Cost of Energy - Gas Fired Peaking Technologies by Capacity Factor (Eastside Med Fuel Forecast)



Transmission Cost

- Fixed Levelized Cost ($/kW-yr) estimates include a transmission charge to bring power to the market
- Currently the BPA point-to-point cost is used ~ $20/kW-yr
- Are there other simple transmission cost estimations to use to reflect incremental system cost?