On Renewable Energy Pricing – Draft 5

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* I have received a great deal of help on this, but am completely responsible for the opinions and many errors that still remain.

Maryland Adds Offshore Wind, As Do Others

- UK – Hornsea 1 & 2 – 1200 and 1400 MW Respectively - https://uk.reuters.com/article/uk-britain-renewables-dong-energy/denmarks-dong-wins-uk-contract-to-build-worlds-largest-offshore-wind-farm-idUKKCN1BM0R1
- China – Offshore in Jiangsu, Zhejiang, Fujian and Guangdong provinces - http://www.renewableenergyworld.com/articles/2017/10/china-makes-a-big-bet-on-offshore-wind.html
- Maryland – 875 MW – Deepwater Wind Holdings LLC – Estimated Cost - $2.9 Billion – (extrapolating $2.5 billion for 750 MW from some years ago - See http://www.uswindinc.com/our-projects/).

Won't Save As Much as Expected – Heat Rates - https://www.eia.gov/electricity/annual/html/epa_08_01.html

Table 8.1. Average Operating Heat Rate for Selected Energy Sources,

Year	Coal	Petroleum	Natural Gas	Nuclear
2005	10373	10631	8551	10436
2006	10351	10809	8471	10435
2007	10375	10794	8403	10489
2008	10378	11015	8305	10452
2009	10414	10923	8160	10459
2010	10415	10984	8185	10452
2011	10444	10829	8152	10464
2012	10498	10991	8039	10479
2013	10459	10713	7948	10449
2014	10428	10814	7907	10459
2015	10495	10687	7878	10458

Not Enough Customers, Either

- $2.9 Billion/20 Years = $145 Million
- $145 Million/12 Months = $12,083,333.33
- $12,083,333.33 / 3 Million Customers = $4.03 per Customer

NG Savings

	Av. Cost NG	3.11	2.488	3.732
		NG Price		
NG Backup	NG Svgs.			
0.6	102270	$2,549,386.56	$2,039,509.25	$3,059,263.87
0.5	127837.5	$3,186,733.20	$2,549,386.56	$3,824,079.84
0.4	153405	$3,824,079.84	$3,059,263.87	$4,588,895.81
0.3	178972.5	$4,461,426.48	$3,569,141.18	$5,353,711.78
0.2	204540	$5,098,773.12	$4,079,018.50	$6,118,527.74

Choice of 20% Backup

- See http://blog.cleanenergy.org/2015/05/28/solar-wind-generation-need-no-backup/
- It is necessary to be clear about this – no change if the system is not growing, but if it is, the 20% becomes a relevant factor in costs

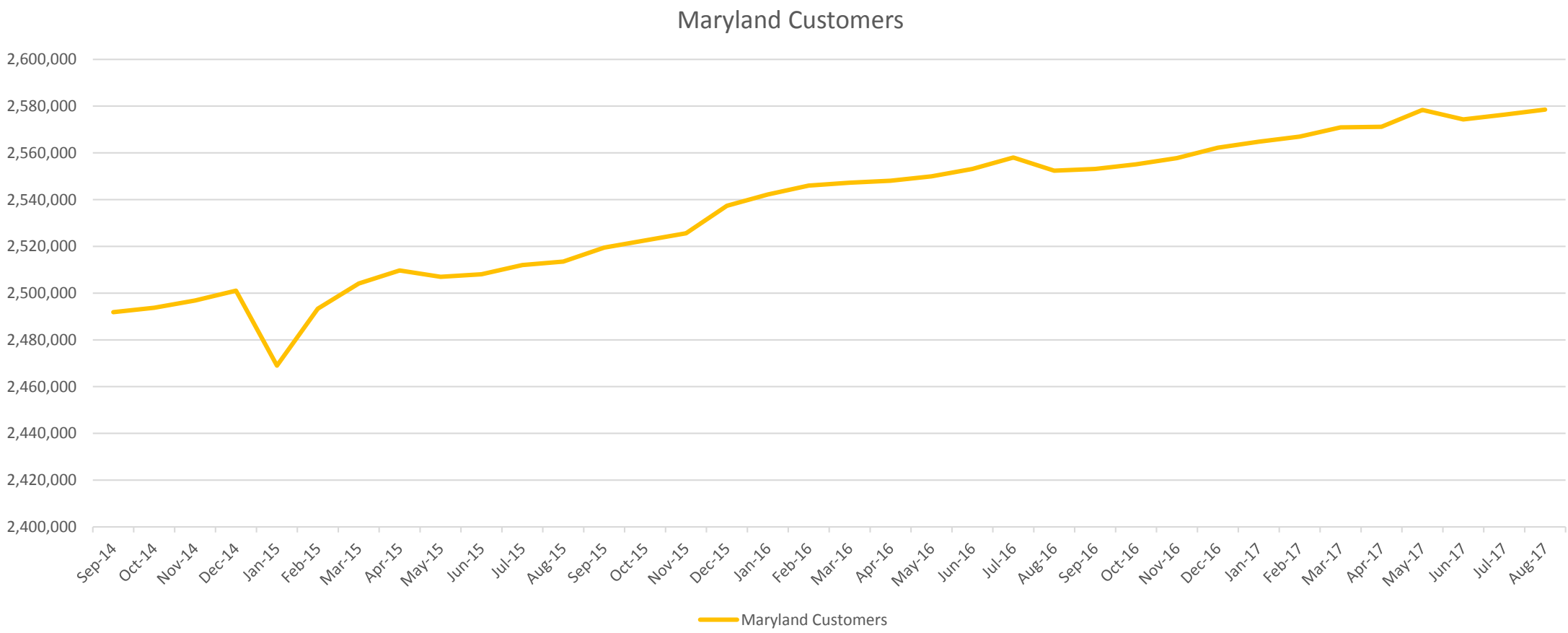
Savings Per Customer for the Various Backups

Per Cust.			
Svgs.	$0.85	$0.68	$1.02
	$1.06	$0.85	$1.27
	$1.27	$1.02	$1.53
	$1.49	$1.19	$1.78
	$1.70	$1.36	$2.04

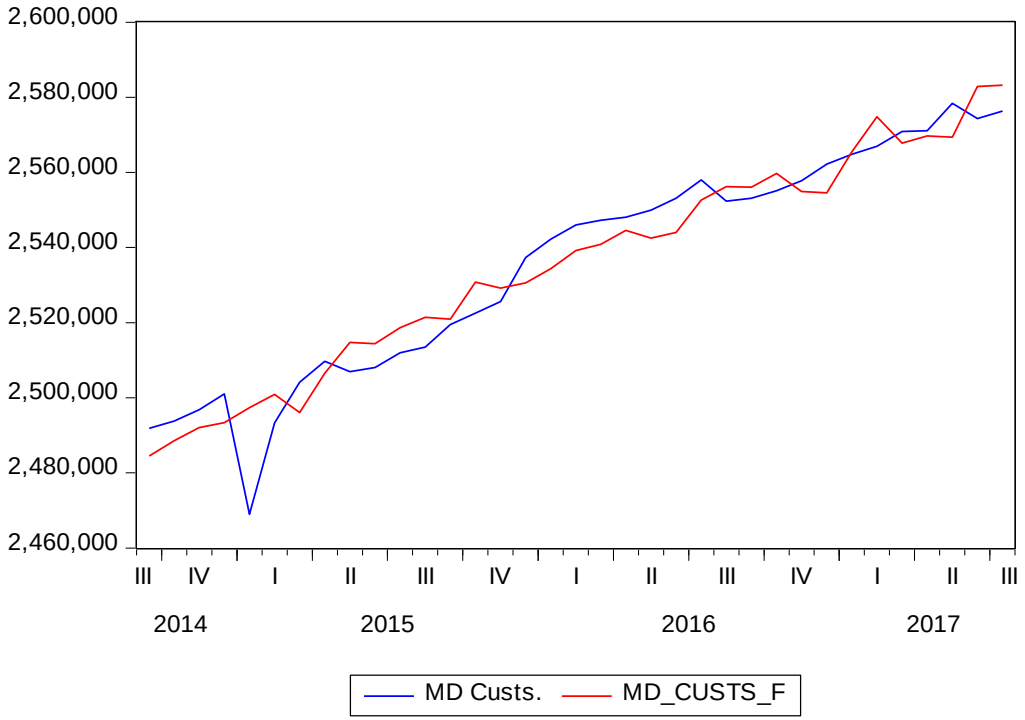
Net Cost – Per Month – If 3 Million Customers

Net Cost			
	$3.18	$3.35	$3.01
	$2.97	$3.18	$2.76
	$2.76	$3.01	$2.50
	$2.54	$2.84	$2.25
	$2.33	$2.67	$1.99

Maryland Customers



Estimated Maryland Customers



A Customer Estimating Equation

Dependent Variable: MD_CUSTS_
Method: Least Squares
Date: 10/24/17 Time: 15:27
Sample: 2014M09 2017M07
Included observations: 35

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	337519.2	107468.6	3.140631	0.0036
MD_EMP_	849.5856	43.93329	19.33808	0.0000
ARM_NR	-31880.77	11092.51	-2.874080	0.0071

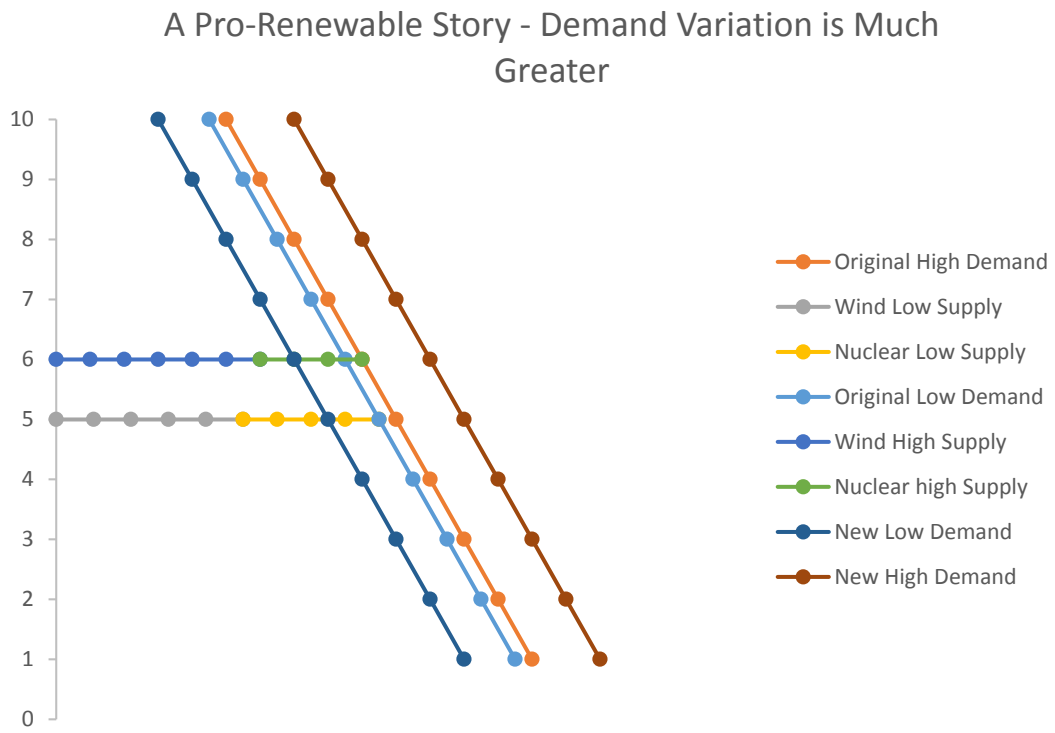
R-squared	0.929175	Mean dependent var	2535235.
Adjusted R-squared	0.924749	S.D. dependent var	29880.68
S.E. of regression	8196.870	Akaike info criterion	20.94271
Sum squared resid	2.15E+09	Schwarz criterion	21.07602
Log likelihood	-363.4974	Hannan-Quinn criter.	20.98873
F-statistic	209.9091	Durbin-Watson stat	1.474767
Prob(F-statistic)	0.000000		

Import Substitution - Already

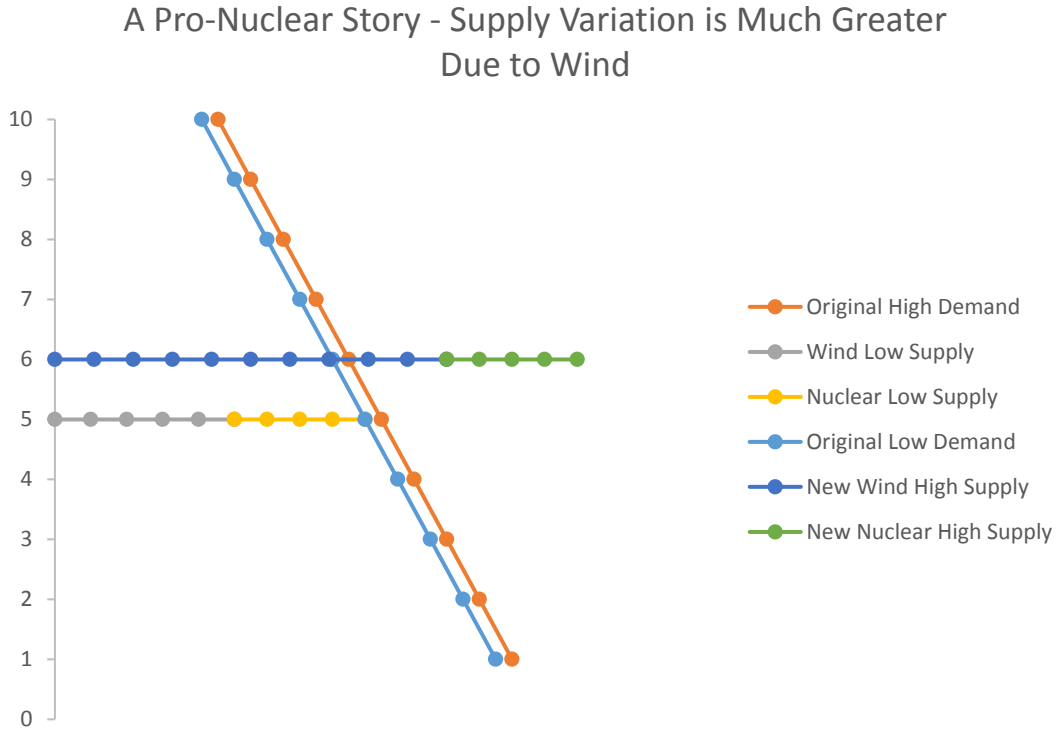
	Import %s	2010					
	< 30%	30%-32%	32%-34%	34%-36%	36%-38%	38%-40%	>40%
	x	x	x	x	x	x	x
	x	x	x	x			
			x				
	Import %s	2016					
	< 30%	30%-32%	32%-34%	34%-36%	36%-38%	38%-40%	>40%
		x	x	x	x	x	x
		x					x
		x					x
							x
							x

The Supply and Demand Arguments for Negative Prices

What Renewable Advocates Might Argue



My Version of Vogel's Story



Ambiguous Results – for Monthly Data

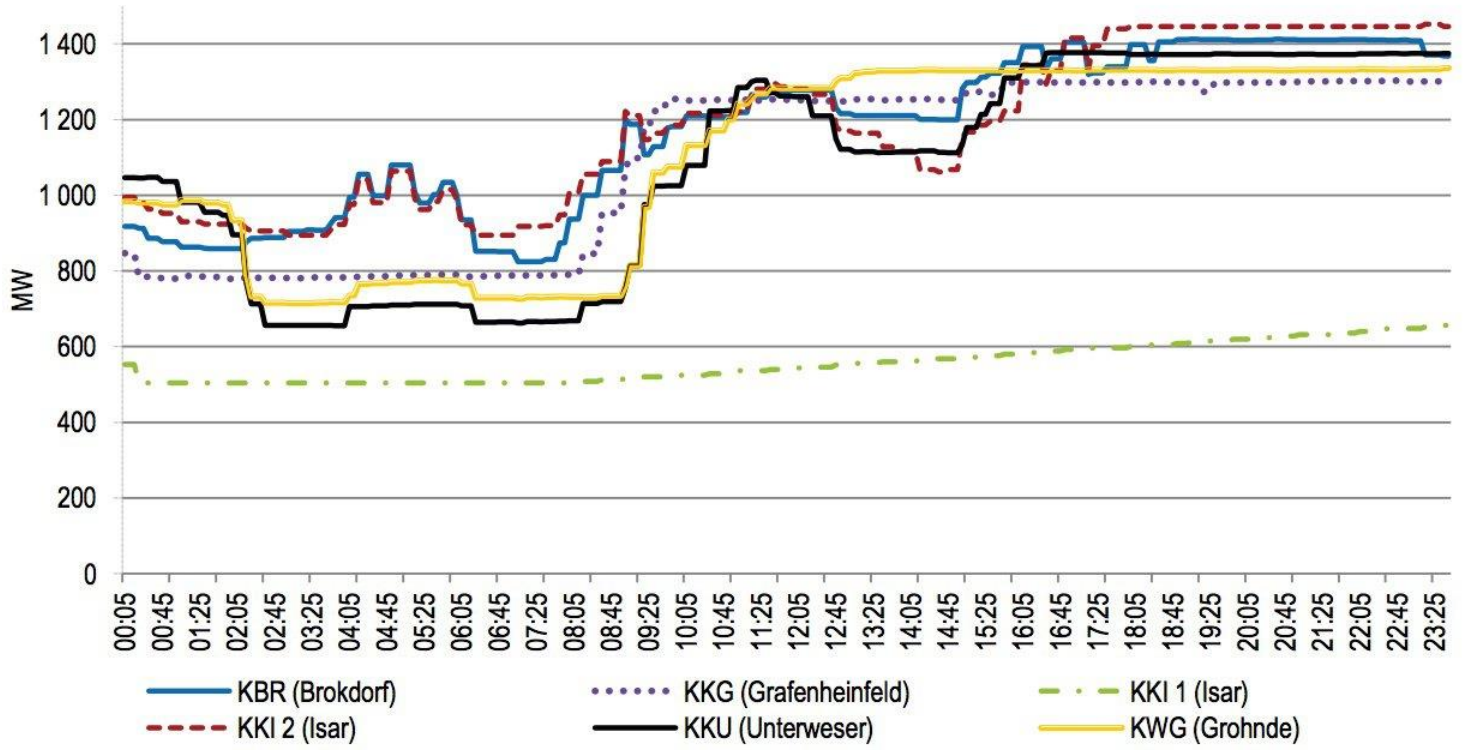
- Both Variances for Supply and Demand Decrease
- 2010 Supply and Demand Variances = 433,618.81 and 578,934.18
- 2016 Supply and Demand Variances = 419,148.99 (a 3.34% decrease) and 542,948.91 (a 6.22% decrease)
- But Import Substitution May Explain Part

For Nuclear and maybe Coal, Subsidies Now

- For Illinois and New York, see https://instituteforenergyresearch.org/analysis/illinois-new-york-rescue-nuclear-plants-states-may-follow/
- Could spread to other states
- Survive one court challenge - https://www.utilitydive.com/news/federal-court-throws-out-challenge-to-new-york-nuclear-subsidies/447871/
- So far, not necessary for Maryland, but Calvert Cliffs could be in trouble by 2020
- Should it be charged to renewables or natural gas? Falling natural gas prices affect both Maryland and Michigan, but Calvert Cliffs not in trouble – *yet*
- Vs. Professor Richard Green, Univ. of London: "Moreover, the reader may allow me to respond to 'This somehow leads him [*moi!*] to conclude that the fossil generators would now have a higher marginal cost than the wind farms and would, therefore, require a subsidy if they were to continue to operate" with some care. If the increased difficulties of nuclear power in Illinois are not *exclusively* because of low natural gas prices, but also because of the renewable portfolio standards, then the "require a subsidy if they were to continue to operate" is exactly what is happening."

What to Do – Flexibility - Expensive

Figure E.2: Example of the electricity generation with some German nuclear power plants.



Courtesy of E.ON Kernkraft

Differing Views on Costs of Nuclear Flexibility

- Optimism - C. Bruynooghe *et. al.*, “Load-following operating mode at Nuclear Power Plants (NPPs) and incidence on Operation and Maintenance (O&M) costs. Compatibility with wind power variability”, European Commission Joint Research Centre (2010); Dr. Michael Fuchs and Wolfgang Timpf, “The Load Change Ability of Nuclear Power Plants – Experience and Outlook”, VGB Congress POWER PLANTS 2011; and Jonas Persson *et. al.*, ELFORSK, “Additional Costs for Load-following Nuclear Power Plants Experiences from Swedish, Finnish, German, and French nuclear power plants”, December 2012.
- Pessimism - Victoria Aleexeva, of the International Atomic Energy Agency. Her “Economic Aspects of Load Following”, Erlangen, Germany October, 2014, and Thure Traber and Claudia Kemfert, “Gone with the wind? -- Electricity market prices and incentives to invest in thermal power plants under increasing wind energy supply“, *Energy Economics*, 2011, vol. 33, issue 2, 249-256. - Ramping cost 88.7 € by MW ramped up

For Coal?

- See especially Alexander Buttler, Christian Kunze and Hartmut Spliethoff, “IGCC–EPI: Decentralized concept of a highly load-flexible IGCC power plant for excess power integration”, *Applied Energy*, Volume 104, April 2013, Pages 869–879.
- No data on costs for this
- Likelihood of any changes being very expensive for both coal and nuclear.