

# Capacity Market Design Proposal

CIFP

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IMM



Monitoring Analytics

# Capacity Market Offers

- **Capacity offered as a sequence of hourly available MW for the delivery year**
- **Capacity offer price is specified in \$/MW-year**
- **Hourly available MW profile accounts for planned and maintenance outages**
- **Forced outage rate reflected in the hourly available MW profile**
- **Adjustments due to ambient conditions are reflected in the hourly available MW profile**
- **Intermittent resources offer available MW for every hour in the delivery year based on hourly historical data**

# Modified Availability Factor

- **Modified Availability Factor (MAF) for the delivery year is the ratio of the total capacity hours that are available to the total installed capacity hours of the resource during the delivery year.**

$$MAF = \frac{\sum_{hour} Available\ MW_{hour}}{ICAP * 8760}$$

- **Offer per available MW**

$$Offer\ (\$/MW - Hour) = \frac{Offer\ (\$/MW - Year)}{MAF * ICAP * 8760}$$



# Example 1: Thermal Resource (MAF = 100%)

Hour	ICAP	Offer (Available MW)	Capacity Revenue Recovery (Available in the Energy Market Same as Cleared in the Capacity Market)
Hour 1	100.0	100.0	\$41.67
Hour 2	100.0	100.0	\$41.67
Hour 3	100.0	100.0	\$41.67
Hour 4	100.0	100.0	\$41.67
Hour 5	100.0	100.0	\$41.67
Hour 6	100.0	100.0	\$41.67
Hour 7	100.0	100.0	\$41.67
Hour 8	100.0	100.0	\$41.67
Hour 9	100.0	100.0	\$41.67
Hour 10	100.0	100.0	\$41.67
Hour 11	100.0	100.0	\$41.67
Hour 12	100.0	100.0	\$41.67
Hour 13	100.0	100.0	\$41.67
Hour 14	100.0	100.0	\$41.67
Hour 15	100.0	100.0	\$41.67
Hour 16	100.0	100.0	\$41.67
Hour 17	100.0	100.0	\$41.67
Hour 18	100.0	100.0	\$41.67
Hour 19	100.0	100.0	\$41.67
Hour 20	100.0	100.0	\$41.67
Hour 21	100.0	100.0	\$41.67
Hour 22	100.0	100.0	\$41.67
Hour 23	100.0	100.0	\$41.67
Hour 24	100.0	100.0	\$41.67
<b>Total</b>			<b>\$1,000.00</b>

- Offer (\$/Year): **\$1,000.00**
- MAF (Percentage): **100%**
- Offer (\$/MW-Hour): **\$0.417**

# Example 2: Thermal Resource (MAF = 90%)

Hour	ICAP	Offer (Available MW)	Capacity Revenue Recovery (Available in the Energy Market Same as Cleared in the Capacity Market)
Hour 1	100.0	90.0	\$41.67
Hour 2	100.0	90.0	\$41.67
Hour 3	100.0	90.0	\$41.67
Hour 4	100.0	90.0	\$41.67
Hour 5	100.0	90.0	\$41.67
Hour 6	100.0	90.0	\$41.67
Hour 7	100.0	90.0	\$41.67
Hour 8	100.0	90.0	\$41.67
Hour 9	100.0	90.0	\$41.67
Hour 10	100.0	90.0	\$41.67
Hour 11	100.0	90.0	\$41.67
Hour 12	100.0	90.0	\$41.67
Hour 13	100.0	90.0	\$41.67
Hour 14	100.0	90.0	\$41.67
Hour 15	100.0	90.0	\$41.67
Hour 16	100.0	90.0	\$41.67
Hour 17	100.0	90.0	\$41.67
Hour 18	100.0	90.0	\$41.67
Hour 19	100.0	90.0	\$41.67
Hour 20	100.0	90.0	\$41.67
Hour 21	100.0	90.0	\$41.67
Hour 22	100.0	90.0	\$41.67
Hour 23	100.0	90.0	\$41.67
Hour 24	100.0	90.0	\$41.67
Total			\$1,000.00

- Offer (\$/Year): \$1,000.00
- MAF (Percentage): 90 %
- Offer (\$/MW-Hour): \$0.463

# Example 3: Solar Resource (MAF = 26%)

Hour	ICAP	Offer (Available MW)	Capacity Revenue Recovery (Available in the Energy Market Same as Cleared in the Capacity Market)
Hour 1	100.0	0.0	\$0.00
Hour 2	100.0	0.0	\$0.00
Hour 3	100.0	0.0	\$0.00
Hour 4	100.0	0.0	\$0.00
Hour 5	100.0	0.0	\$0.00
Hour 6	100.0	0.0	\$0.00
Hour 7	100.0	0.3	\$0.46
Hour 8	100.0	4.4	\$7.00
Hour 9	100.0	27.5	\$43.68
Hour 10	100.0	55.9	\$88.78
Hour 11	100.0	62.7	\$99.62
Hour 12	100.0	78.5	\$124.70
Hour 13	100.0	88.2	\$140.27
Hour 14	100.0	86.9	\$138.13
Hour 15	100.0	83.5	\$132.74
Hour 16	100.0	78.8	\$125.27
Hour 17	100.0	43.7	\$69.50
Hour 18	100.0	17.0	\$27.10
Hour 19	100.0	1.3	\$2.10
Hour 20	100.0	0.4	\$0.64
Hour 21	100.0	0.0	\$0.00
Hour 22	100.0	0.0	\$0.00
Hour 23	100.0	0.0	\$0.00
Hour 24	100.0	0.0	\$0.00
Total			\$1,000.00

- Offer (\$/Year): 1,000
- MAF (Percentage): 26 %
- Offer (\$/MW-Hour): \$1.590

# Example 4: Thermal Resource (MAF = 83%)

Hour	Outage	ICAP	Offer (Available MW)	Capacity Revenue (Available in the Energy Market as Cleared in the Capacity Market)	Recovery (MW Available in the Energy Market (Random Outages))	Capacity Revenue Recovery (Random Outages)
Hour1		100.0	90.0	\$45.45	80.7	\$40.77
Hour2		100.0	90.0	\$45.45	98.6	\$49.79
Hour3		100.0	90.0	\$45.45	93.4	\$47.17
Hour4		100.0	90.0	\$45.45	92.2	\$46.55
Hour5	Planned	100.0	0.0	\$0.00	0.0	\$0.00
Hour6	Planned	100.0	0.0	\$0.00	0.0	\$0.00
Hour7		100.0	90.0	\$45.45	80.1	\$40.48
Hour8		100.0	90.0	\$45.45	92.1	\$46.54
Hour9		100.0	90.0	\$45.45	82.1	\$41.49
Hour10		100.0	90.0	\$45.45	81.0	\$40.89
Hour11		100.0	90.0	\$45.45	89.1	\$44.99
Hour12		100.0	90.0	\$45.45	82.8	\$41.84
Hour13		100.0	90.0	\$45.45	96.1	\$48.54
Hour14		100.0	90.0	\$45.45	85.4	\$43.12
Hour15		100.0	90.0	\$45.45	96.0	\$48.47
Hour16		100.0	90.0	\$45.45	91.1	\$45.99
Hour17		100.0	90.0	\$45.45	81.1	\$40.98
Hour18		100.0	90.0	\$45.45	98.6	\$49.82
Hour19		100.0	90.0	\$45.45	84.0	\$42.45
Hour20		100.0	90.0	\$45.45	98.5	\$49.75
Hour21		100.0	90.0	\$45.45	97.1	\$49.02
Hour22		100.0	90.0	\$45.45	97.2	\$49.07
Hour23		100.0	90.0	\$45.45	93.5	\$47.22
Hour24		100.0	90.0	\$45.45	89.3	\$45.08
Total			1,980.0	\$1,000.00	1,980.0	\$1,000.00

- Offer (\$/Year): 1,000.00
- MAF (Percentage): 83 %
- Offer (\$/MW-Hour): \$0.505

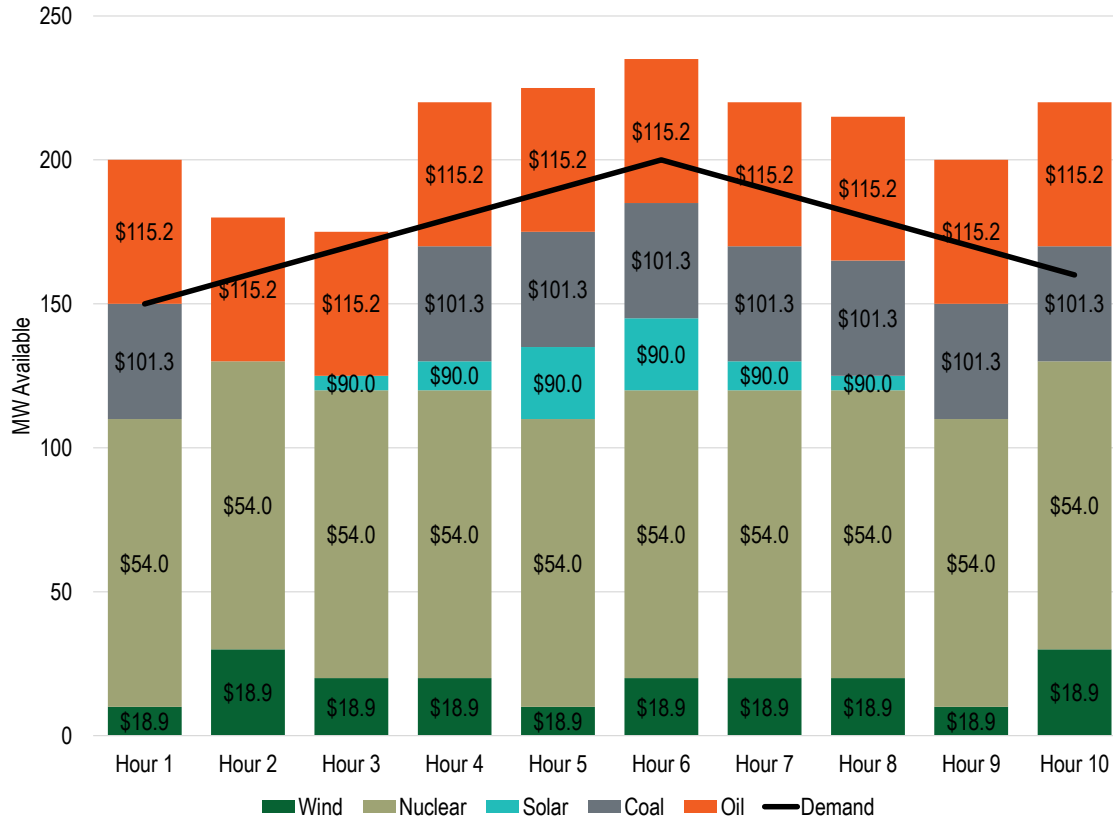
# Capacity Market Auction Clearing

- **Demand is specified as a sequence of hourly reliability requirements**
- **Objective is to select the least cost set of resources that simultaneously satisfy reliability requirements of all hours in the delivery year**
- **Clearing price for the delivery year is set by the offer price of the marginal resource**





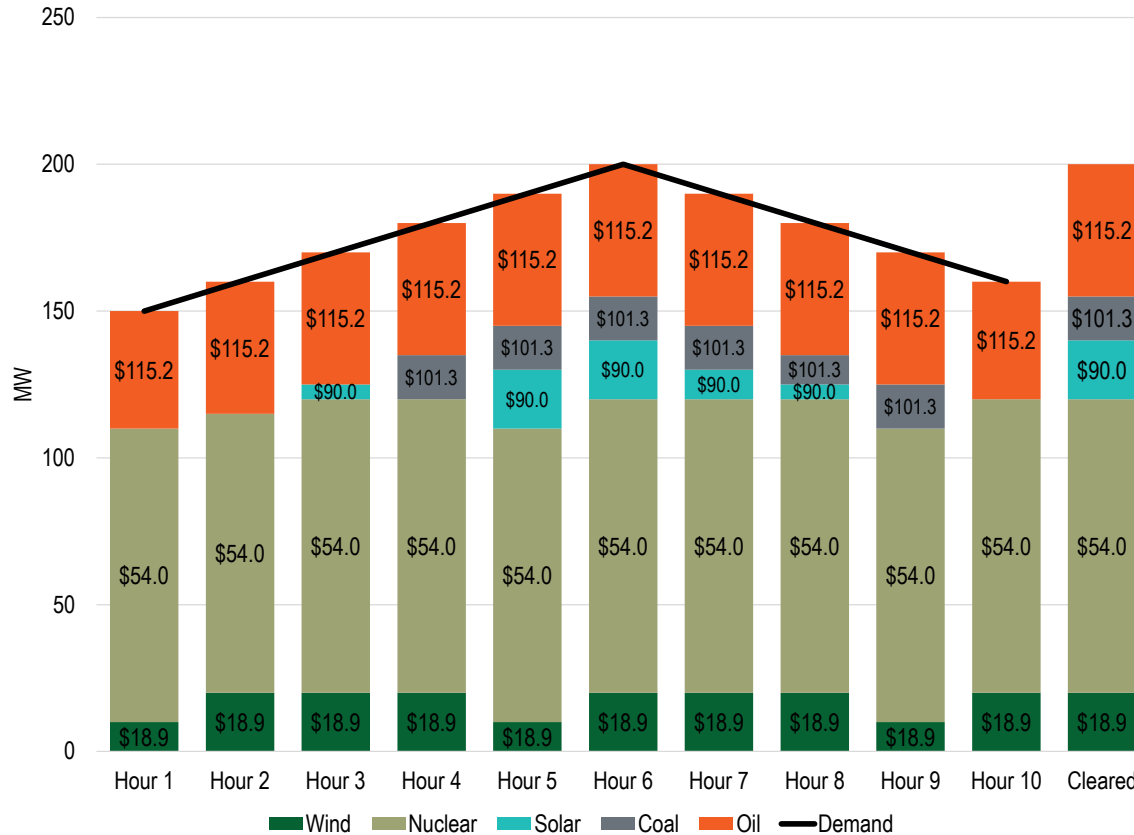
# Example: Offers



	Availability (MW)										ICAP
	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	MW
Nuclear	100	100	100	100	100	100	100	100	100	100	100
Solar	0	0	5	10	25	25	10	5	0	0	40
Wind	10	30	20	20	10	20	20	20	10	30	40
Coal	40	0	0	40	40	40	40	40	40	40	50
Oil	50	50	50	50	50	50	50	50	50	50	70

	ICAP	Offer		Offer
	MW	MAF	(\$/DY)	(\$/MW-Hour)
Nuclear	100.0	1.000	\$54,000.00	\$54.00
Solar	40.0	0.200	\$7,200.00	\$90.00
Wind	40.0	0.475	\$3,600.00	\$18.95
Coal	50.0	0.640	\$32,400.00	\$101.25
Oil	70.0	0.714	\$57,600.00	\$115.20

# Example: Clearing



	Availability (MW)										ICAP MW
	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	
Nuclear	100	100	100	100	100	100	100	100	100	100	100
Solar	0	0	5	10	25	25	10	5	0	0	40
Wind	10	30	20	20	10	20	20	20	10	30	40
Coal	40	0	0	40	40	40	40	40	40	40	50
Oil	50	50	50	50	50	50	50	50	50	50	70

	ICAP MW	Offer MAF	Offer (\$/DY)	Offer (\$/MW-Hour)	Cleared (UCAP MW)	Clearing Price (\$/MW-Hour)
Nuclear	100.0	1.000	\$54,000.00	\$54.00	100.0	\$115.20
Solar	40.0	0.200	\$7,200.00	\$90.00	20.0	\$115.20
Wind	40.0	0.475	\$3,600.00	\$18.95	20.0	\$115.20
Coal	50.0	0.640	\$32,400.00	\$101.25	15.0	\$115.20
Oil	70.0	0.714	\$57,600.00	\$115.20	45.0	\$115.20

Oil resource is marginal

# Example: Capacity Revenue

	ICAP		Offer	Offer	Cleared	Clearing Price	Capacity Revenue	Makewhole <sup>1</sup>	Total Revenue
	MW	MAF	(\$/DY)	(\$/MW-Hour)	(UCAP MW)	(\$/MW-Hour)	(\$/DY)	(\$/DY)	(\$/DY)
Nuclear	100.0	1.000	\$54,000.00	\$54.00	100.0	\$115.20	\$115,200.00	\$0.00	\$115,200.00
Solar	40.0	0.200	\$7,200.00	\$90.00	20.0	\$115.20	\$23,040.00	\$0.00	\$23,040.00
Wind	40.0	0.475	\$3,600.00	\$18.95	20.0	\$115.20	\$23,040.00	\$0.00	\$23,040.00
Coal	50.0	0.640	\$32,400.00	\$101.25	15.0	\$115.20	\$17,280.00	\$15,120.00	\$32,400.00
Oil	70.0	0.714	\$57,600.00	\$115.20	45.0	\$115.20	\$51,840.00	\$5,760.00	\$57,600.00

1. Similar to current capacity market rules, makewhole payment would be paid to inflexibly offered resources that clear partially in the auction.

# Capacity Revenue Payment

- **If the capacity resource's availability in the energy market (actual MAF) matches their offered availability in the capacity market (target MAF), the resource would recover full capacity market payment**



# Example: Capacity Revenue Payment

	Availability Offered (MW)										Target	
	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	MAF	
Nuclear	100	100	100	100	100	100	100	100	100	100	100	1.000
Solar	0	0	5	10	25	25	10	5	0	0	0	0.200
Wind	10	30	20	20	10	20	20	20	10	30	0.475	
Coal	40	0	0	40	40	40	40	40	40	40	40	0.640
Oil	50	50	50	50	50	50	50	50	50	50	50	0.714

	Availability in the Energy Market (MW)										Actual	
	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	MAF	
Nuclear	100	100	100	100	100	100	100	100	100	100	100	1.000
Solar	0	0	0	5	35	35	5	0	0	0	0	0.200
Wind	10	30	20	20	10	20	20	20	10	30	0.475	
Coal	30	0	20	20	40	50	40	30	50	40	40	0.640
Oil	70	70	0	70	50	50	50	50	50	40	40	0.714

	Capacity Revenue (\$/Hour)										Total	Offer
	Hour1	Hour2	Hour3	Hour4	Hour5	Hour6	Hour7	Hour8	Hour9	Hour10	(\$/DY)	(\$/DY)
Nuclear	\$11,520	\$11,520	\$11,520	\$11,520	\$11,520	\$11,520	\$11,520	\$11,520	\$11,520	\$11,520	\$115,200	\$54,000
Solar	\$0	\$0	\$0	\$1,440	\$10,080	\$10,080	\$1,440	\$0	\$0	\$0	\$23,040	\$7,200
Wind	\$1,213	\$3,638	\$2,425	\$2,425	\$1,213	\$2,425	\$2,425	\$2,425	\$1,213	\$3,638	\$23,040	\$3,600
Coal	\$3,038	\$0	\$2,025	\$2,025	\$4,050	\$5,063	\$4,050	\$3,038	\$5,063	\$4,050	\$32,400	\$32,400
Oil	\$8,064	\$8,064	\$0	\$8,064	\$5,760	\$5,760	\$5,760	\$5,760	\$5,760	\$4,608	\$57,600	\$57,600


# Clearing Price

- **Clearing price for the delivery year is set by the offer price of the marginal resource**
- **Marginal capacity satisfies simultaneous incremental increase in demand of every hour in the delivery year**



# Example: Clearing Price

Hour	Change in the Objective (\$/MW-Hour)
Hour1 Only	\$0.00
Hour2 Only	\$0.00
Hour3 Only	\$13.95
Hour4 Only	\$0.00
Hour5 Only	\$90.00
Hour6 Only	\$90.00
Hour7 Only	\$11.25
Hour8 Only	\$0.00
Hour9 Only	\$11.25
Hour10 Only	\$0.00
All Hours Simultaneously	\$115.20



**Monitoring Analytics, LLC**

**2621 Van Buren Avenue**

**Suite 160**

**Eagleville, PA**

**19403**

**(610) 271-8050**

**[MA@monitoringanalytics.com](mailto:MA@monitoringanalytics.com)**

**[www.MonitoringAnalytics.com](http://www.MonitoringAnalytics.com)**

