



# Interim Incremental Auction Revenue Rights Allocation Example

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## Objectives

**At the completion of this presentation, you should be able to understand the concepts and principles of Interim Incremental ARR's.**

This presentation distributes revenues from the FTR Auction example I wrote for section 6 of Manual 06 located on [http://www.iso-ne.com/cmsmss/Standard\\_Market\\_Design/Draft\\_Manuals/Manual 06](http://www.iso-ne.com/cmsmss/Standard_Market_Design/Draft_Manuals/Manual_06)



## Agenda

- Introduction to Interim Incremental ARR
- Introduction to the PJM Five-Bus Power System Model used in the Examples
- Overview of the Annual and Monthly FTR Auction Examples from Manual 6
- Review the Interim Incremental ARR Examples on the assignment of FTR Auction Revenues to Eligible Transmission Upgrades
- Summary of Payments to Eligible Transmission Upgrades for the Annual and Monthly FTR Auction Examples



# Understanding Interim Incremental ARR



## What are Interim Incremental ARR's?

### Interim Incremental ARR's are ...

- An Interim Incremental ARR provides a right to entities who provide an upgrade to the transmission system which is not included in the Pool RNS Rate to receive ARR's that are consistent with the increase in FTR's that clear the FTR Auction as a result of the transmission upgrade.
- Interim Incremental ARR's awarded to an entity who pays for transmission upgrades will not be subject to reduction in Stages 2, 3, and 4 of the ARR Allocation process.
- The Interim Incremental ARR (IIARR) methodology is to be effective until the advent of the first Annual FTR Auction (tentatively scheduled for April 2004).

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## How are Interim Incremental ARR's obtained?

### Interim Incremental ARR's are obtained through the auction ...

- The award is in direct proportion to the percentage of the costs of the upgrade paid for by an entity to the extent that the costs are not reimbursable under the Pool RNS Rate.
- The FTR Auction is conducted with and without the eligible transmission upgrade and the difference in FTR's are priced at the FTR Auction's Clearing Price yielding the IIARR payment for the upgrade.

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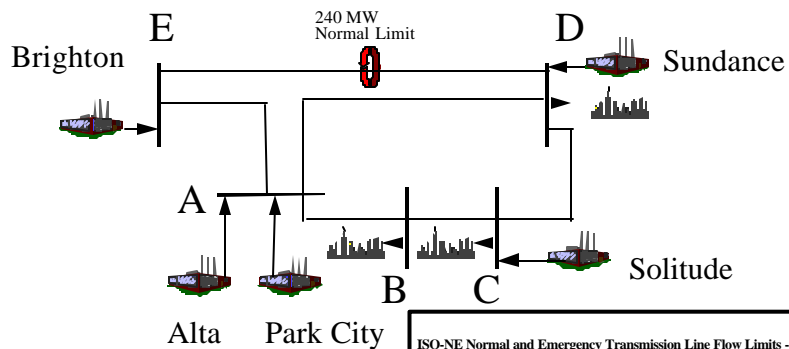


# The Five Bus Power System Model



## The PJM Five Bus Power System Model

In this example, all transmission lines shown are double circuits on a single tower which are subject to loss of both lines under a line contingency.



ISO-NE Normal and Emergency Transmission Line Flow Limits - MW						
Line	E-D	E-A	D-C	C-B	B-A	A-D
Normal Limits	240	400	240	350	250	150
Emergency Limits	440	600	440	550	450	350
Reactance	2.97%	0.64%	2.97%	1.08%	2.81%	3.04%



## Transmission Line Upgrades

Line	Effective Date	Eligibility for IIARR Treatment
E-A Upgrade	May-02	100%
C-B Upgrade	Feb-02	100%
B-A Upgrade	Jul-01	0%
E-D Upgrade	Mar-01	50%
D-C Upgrade	Jan-00	0%
A-D Upgrade	Aug-99	50%

Portions of upgrades that are not eligible to receive IIARR Treatment are financially allocated to ARR Holders through the four-stage ARR process.



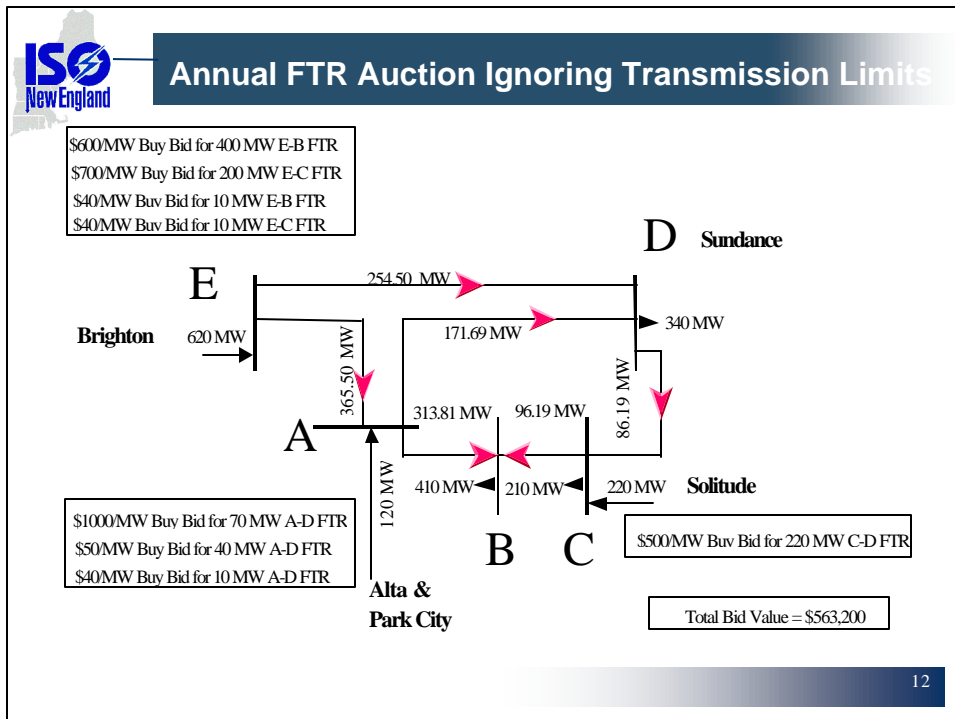
## Normal Line Ratings for Eligible Upgrades (MW)

	E-D	E-A	D-C	C-B	B-A	A-D
Post E-A Upgrade Ratings	240	400	240	350	250	150
Pre E-A Upgrade Ratings	240	200	240	350	250	150
Post C-B Upgrade Ratings	240	200	240	350	250	150
Pre C-B Upgrade Ratings	240	200	240	175	250*	150
Post E-D Upgrade Ratings	240	200	240	175	125*	150
Pre E-D Upgrade Ratings	120	200	240*	175	125	150
Post A-D Upgrade Ratings	120	200	120*	175	125	150
Pre A-D Upgrade Ratings	120	200	120	175	125	75

\* Reflects the effect of upgrades not eligible for IIARR Treatment.

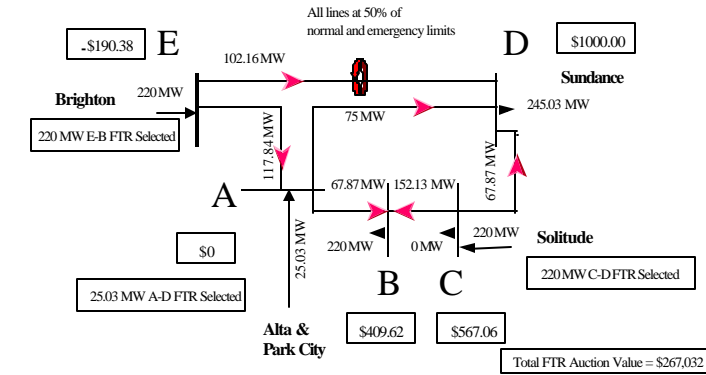


# Annual FTR Auction Example





## Annual FTR Auction Respecting Transmission Limits



Transmission Line	Pre-Contingency Line Flows with All Lines In-Service	50% of Normal Limits	Post-Contingency Line Flows after Loss of Indicated Line						50% of Emergency Limits
			E-D	E-A	D-C	C-B	B-A	A-D	
E-D	102.16	120	0.00	220.00	133.19	32.62	133.19	151.30	220
E-A	117.84	200	220.00	0.00	86.81	187.38	86.81	68.70	300
D-C	-67.87	120	-99.24	-31.69	0.00	-220.00	0.00	-93.73	220
C-B	152.13	175	120.76	188.31	220.00	0.00	220.00	126.27	275
B-A	-67.87	125	-99.24	-31.69	0.00	-220.00	0.00	-93.73	225
A-D	75.00	75	145.79	-6.65	111.84	-7.58	111.84	0.00	175



## Annual FTR Auction Clearing Prices

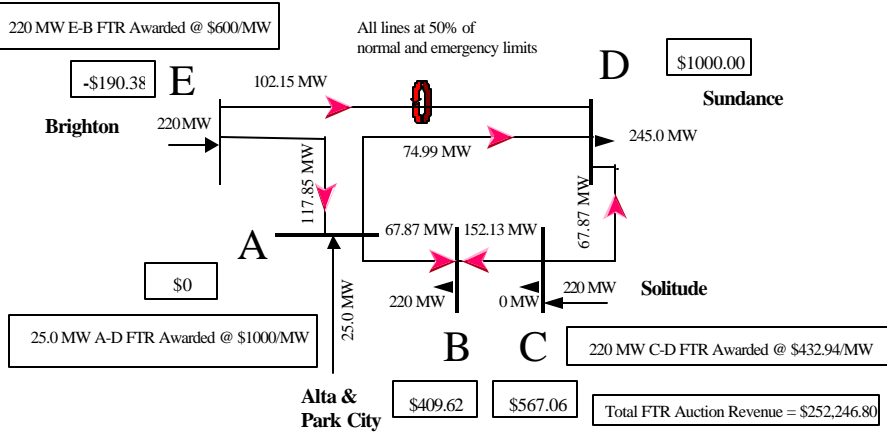
From Bus A	Calculation for Components of FTR Clearing Price		FTR Clearing Price = $\sum$ Cost Components
	Binding Constraint A-D	Binding Constraint E-D	
A	Reference	Reference	\$0.00
B	\$409.62	\$0.00	\$409.62
C	\$567.06	\$0.00	\$567.06
D	\$1000.00	\$0.00	\$1000.00
E	\$177.285	-\$367.664	-\$190.38

### Annual FTR Auction Clearing Prices by Path - \$/MW

Source \ Sink	A	B	C	D	E
A	0	409.62	567.06	1000	-190.38
B	-409.62	0	157.44	590.38	-600
C	-567.06	-157.44	0	432.94	-757.44
D	-1000	-590.38	-432.94	0	-1190.38
E	190.38	600	757.44	1190.38	0



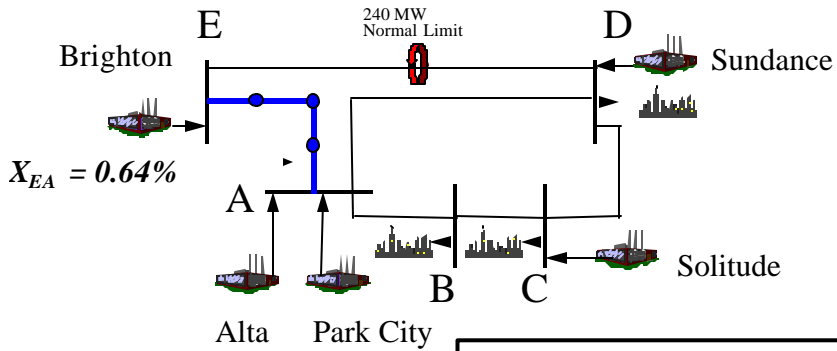
## Annual FTR Auction Results



## Interim Incremental ARR Allocation of Annual FTR Auction Revenues



## The Five Bus Model - Post Line E-A Upgrade

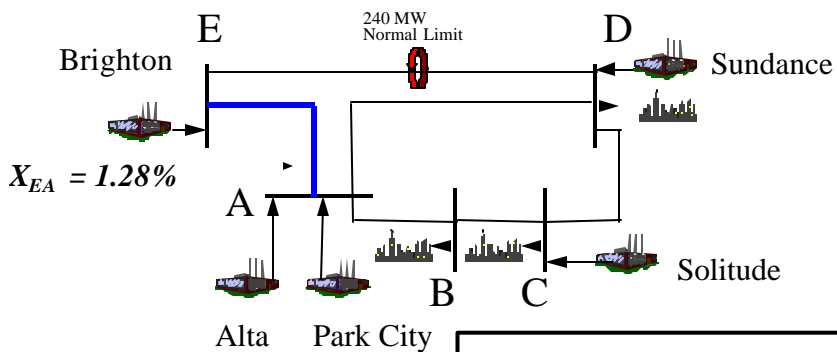


ISO-NE Normal and Emergency Transmission Line Flow Limits - MW						
Line	E-D	E-A	D-C	C-B	B-A	A-D
Normal Limits	240	400	240	350	250	150
Emergency Limits	440	600	440	550	450	350
Reactance	2.97%	0.64%	2.97%	1.08%	2.81%	3.04%

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## The Five Bus Model - Pre Line E-A Upgrade

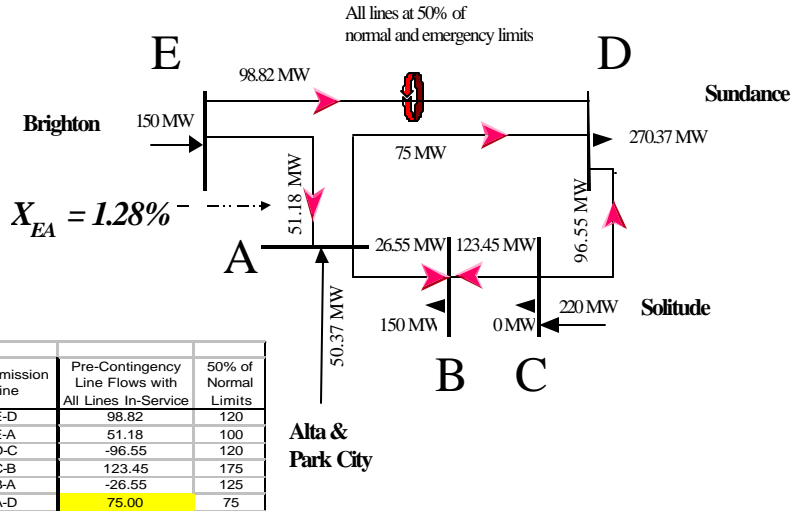


ISO-NE Normal and Emergency Transmission Line Flow Limits - MW						
Line	E-D	E-A	D-C	C-B	B-A	A-D
Normal Limits	240	200	240	350	250	150
Emergency Limits	440	300	440	550	450	350
Reactance	2.97%	1.28%	2.97%	1.08%	2.81%	3.04%

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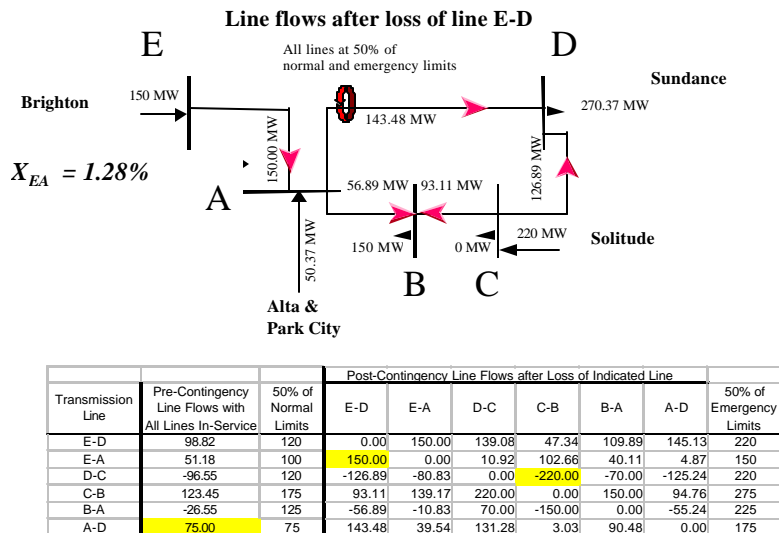
## Comparison of Line Flows with Limits - MW



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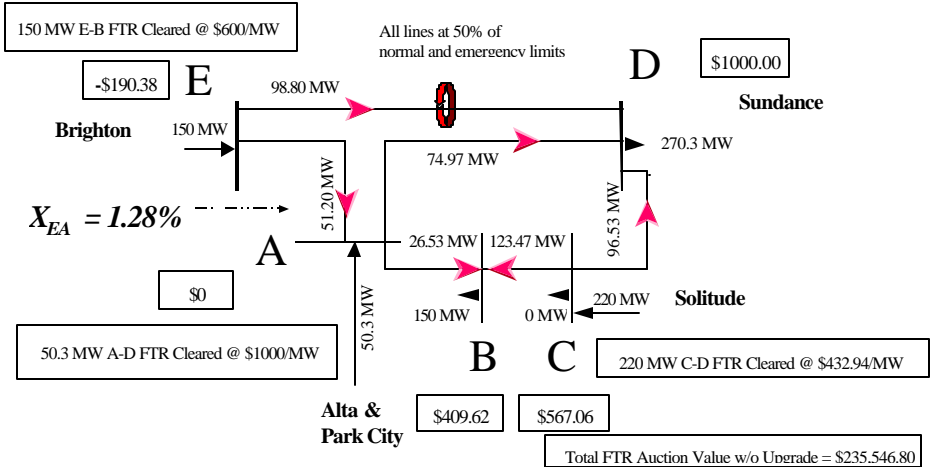
## Contingency Line Flows Compared with Limits - MW



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## Annual FTR Auction Results without Line E-A Upgrade



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## Interim Incremental ARR Payment

The Interim Incremental ARR payment is the difference in value between the Annual FTR Auction results with and without the eligible transmission upgrade:

	Annual FTR Auction \$
With E-A Upgrade	252,246.80
Without E-A Upgrade	235,546.80
Total E-A IIARR Payment	16,700.00

The IIARR would be settled monthly for the duration of the effective period of the FTR Auction (e.g.  $16,700 / 12 = 1,391.66$  month).

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## Incremental FTRs & \$ due to Eligible Upgrades

	E-B FTR	E-C FTR	C-D FTR	A-D FTR	Total	Differences
FTR Clearing Price (CP \$/MW)	600	757.44	432.94	1000		
Post E-A Upgrade - FTR MW	220	0	220	25	465	44.7
Pre E-A Upgrade - FTR MW	150	0	220	50.3	420.3	
Post E-A Upgrade - FTR MW*CP	\$132,000	\$0	\$95,247	\$25,000	\$252,247	\$16,700
Pre E-A Upgrade - FTR MW*CP	\$90,000	\$0	\$95,247	\$50,300	\$235,547	
Post C-B Upgrade - FTR MW	150	0	220	50.3	420.3	19.6
Pre C-B Upgrade - FTR MW	106.6	43.3	180.8	70	400.7	
Post C-B Upgrade - FTR MW*CP	\$90,000	\$0	\$95,247	\$50,300	\$235,547	-\$9,486
Pre C-B Upgrade - FTR MW*CP	\$63,960	\$32,797	\$78,276	\$70,000	\$245,033	
Post E-D Upgrade - FTR MW	67.5	82.4	220	39.2	409.1	66.8
Pre E-D Upgrade - FTR MW	27.5	82.4	220	12.4	342.3	
Post E-D Upgrade - FTR MW*CP	\$40,500	\$62,413	\$95,247	\$39,200	\$237,360	\$50,800
Pre E-D Upgrade - FTR MW*CP	\$16,500	\$62,413	\$95,247	\$12,400	\$186,560	
Post A-D Upgrade - FTR MW	46.3	63.6	173.6	12.4	295.9	54.8
Pre A-D Upgrade - FTR MW	88.7	21.2	131.2	0	241.1	
Post A-D Upgrade - FTR MW*CP	\$27,780	\$48,173	\$75,158	\$12,400	\$163,512	\$37,432
Pre A-D Upgrade - FTR MW*CP	\$53,220	\$16,058	\$56,802	\$0	\$126,079	

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## Compensation for Eligible Upgrades

Line	Auction Revenues due to Upgrade	Eligibility for IIARR Treatment	Payout
E-A Upgrade	\$16,700	100%	\$16,700
C-B Upgrade	-\$9,486	100%	\$0 <sup>1</sup>
E-D Upgrade	\$50,800	50%	\$25,400
A-D Upgrade	\$37,432	50%	\$18,716

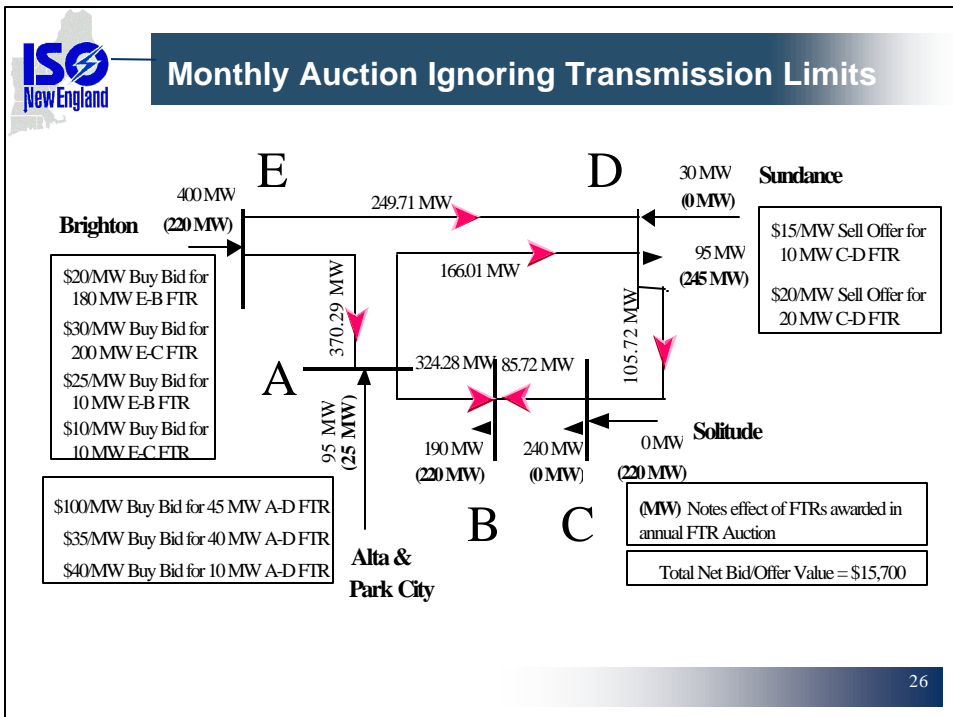
These IIARR would be settled monthly for the duration of the effective period of the FTR Auction (e.g.  $16,700 / 12 = 1,391.66$  month).

<sup>1</sup> Eligible IIARR Holders will not be charged for financial liabilities arising out of auction values that decrease as a result of an upgrade.

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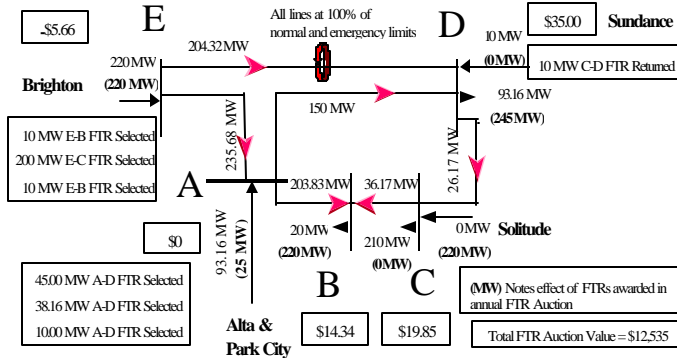


# Monthly FTR Auction Example





## Monthly FTR Auction Respecting Transmission Limits



Transmission Line	Pre-Contingency Line Flows with All Lines In-Service	100% of Normal Limits	Post-Contingency Line Flows after Loss of Indicated Line						100% of Emergency Limits
			E-D	E-A	D-C	C-B	B-A	A-D	
E-D	204.32	240	0.00	440.00	192.36	187.79	297.50	302.60	440
E-A	235.68	400	440.00	0.00	247.64	252.21	142.50	137.40	600
D-C	26.17	240	-36.57	98.54	0.00	-10.00	230.00	-25.55	440
C-B	36.17	350	-26.57	108.54	10.00	0.00	240.00	-15.55	550
B-A	-203.83	250	-266.57	-131.46	-230.00	-240.00	0.00	-255.55	450
A-D	150.00	150	291.58	-13.31	135.80	130.37	260.65	0.00	350

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## Monthly FTR Auction Clearing Prices

From Bus A	Calculation for Components of FTR Clearing Price		FTR Clearing Price = S Cost Components
	Binding Constraint A-D	Binding Constraint E-D	
A	Reference	Reference	\$0.00
B	\$14.34	\$0.00	\$14.34
C	\$19.85	\$0.00	\$19.85
D	\$35.00	\$0.00	\$35.00
E	\$6.205	-\$11.868	-\$5.66

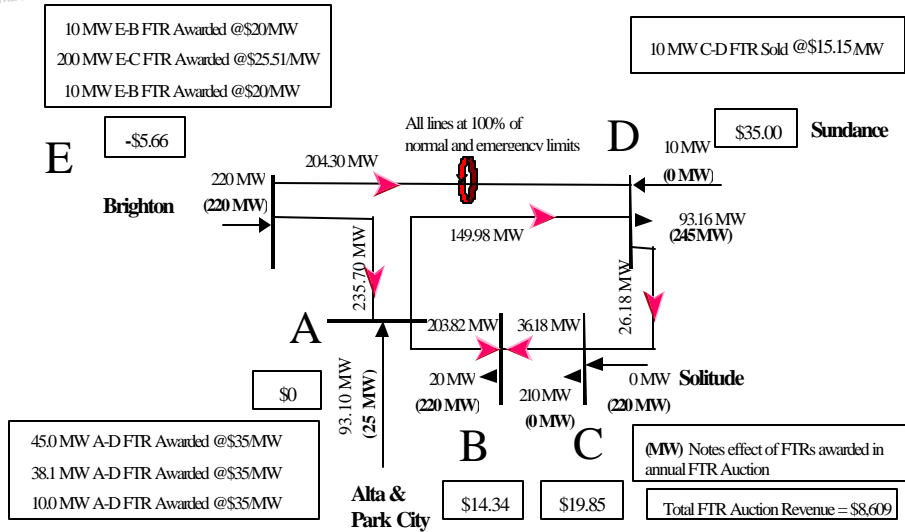
Monthly FTR Auction Clearing Prices by Path - \$/MW

Sink Source	A	B	C	D	E
A	0	14.34	19.85	35	-5.66
B	-14.34	0	5.51	20.66	-20
C	-19.85	-5.51	0	15.15	-25.51
D	-35	-20.66	-15.15	0	-40.66
E	5.66	20	25.51	40.66	0

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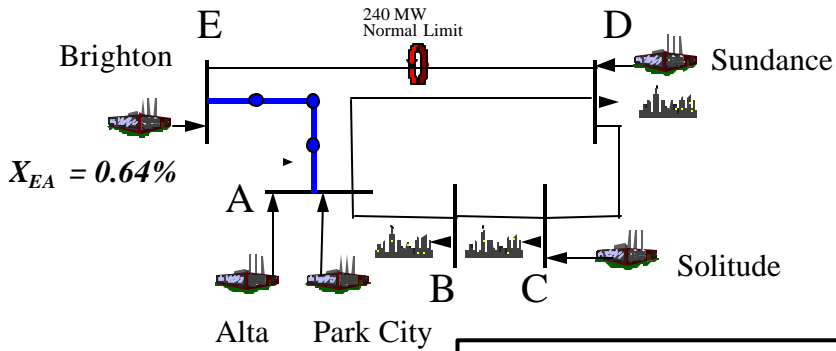
## Monthly FTR Auction Results



## Interim Incremental ARR Allocation of Monthly FTR Auction Revenues



## The Five Bus Model - Post Line E-A Upgrade

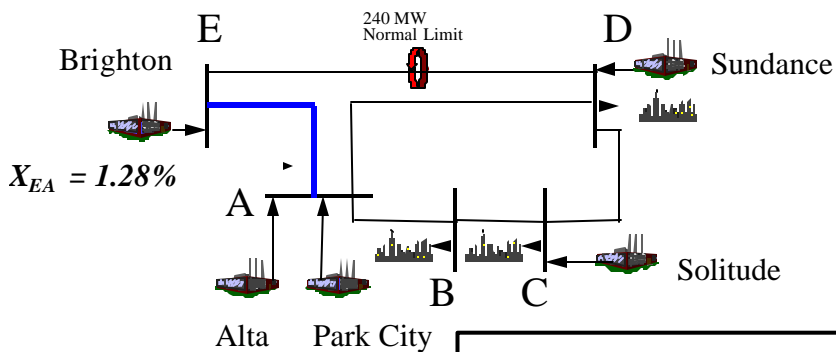


ISO-NE Normal and Emergency Transmission Line Flow Limits - MW						
Line	E-D	E-A	D-C	C-B	B-A	A-D
Normal Limits	240	400	240	350	250	150
Emergency Limits	440	600	440	550	450	350
Reactance	2.97%	0.64%	2.97%	1.08%	2.81%	3.04%

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## The Five Bus Model - Pre Line E-A Upgrade

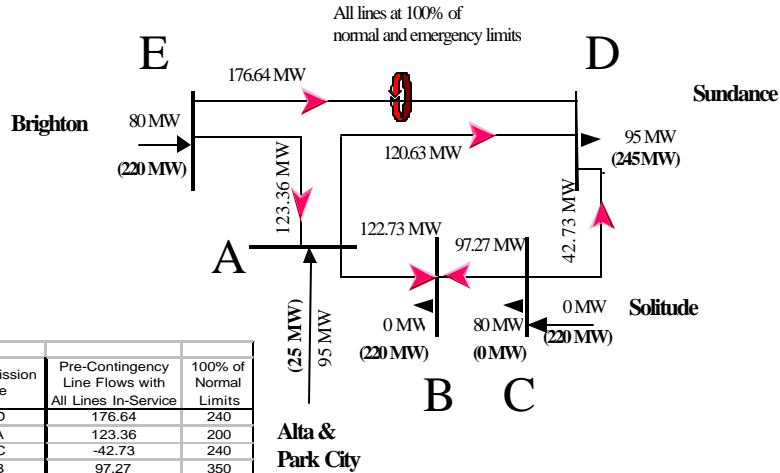


ISO-NE Normal and Emergency Transmission Line Flow Limits - MW						
Line	E-D	E-A	D-C	C-B	B-A	A-D
Normal Limits	240	200	240	350	250	150
Emergency Limits	440	300	440	550	450	350
Reactance	2.97%	1.28%	2.97%	1.08%	2.81%	3.04%

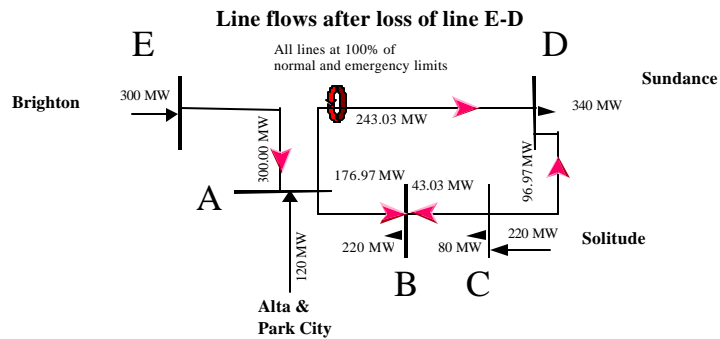
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## Comparison of Line Flows with Limits - MW



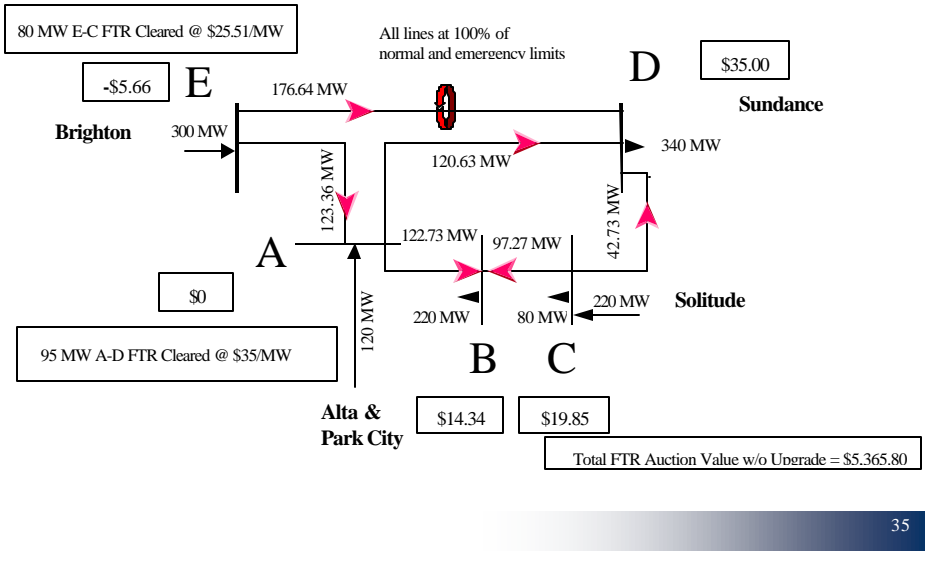
## Contingency Line Flows Compared with Limits - MW



Transmission Line	Pre-Contingency Line Flows with All Lines In-Service	100% of Normal Limits	Post-Contingency Line Flows after Loss of Indicated Line						100% of Emergency Limits
			E-D	E-A	D-C	C-B	B-A	A-D	
E-D	176.64	240	0.00	300.00	194.46	136.08	227.82	251.13	440
E-A	123.36	200	300.00	0.00	105.54	163.92	72.18	48.87	300
D-C	-42.73	240	-96.97	-4.85	0.00	-140.00	80.00	-88.87	440
C-B	97.27	350	43.03	135.15	140.00	0.00	220.00	51.13	550
B-A	-122.73	250	-176.97	-84.85	-80.00	-220.00	0.00	-168.87	450
A-D	120.63	150	243.03	35.15	145.54	63.92	192.18	0.00	350



## Monthly FTR Auction Results without Line E-A Upgrade



## Interim Incremental ARR Payment

The Interim Incremental ARR payment is the difference in value between the Monthly FTR Auction results with and without the eligible transmission upgrade:

	Monthly FTR Auction \$
With E-A Upgrade	8,609.00
Without E-A Upgrade	5,365.80
Total E-A IIARR Value	3,243.20

Since half of the value of the upgrade was settled in the Annual FTR Auction Example, half of the value of the upgrade is settled in the Monthly FTR Auction. Therefore the IIARR would be settled at  $\$3,243.20 / 2 = \$1,621.60$  for the month.



## Incremental FTRs & \$ due to Eligible Upgrades

	E-B FTR	E-C FTR	A-D FTR	D-C FTR	Total	Differences
FTR Clearing Price (CP \$/MW)	20	25.51	35	-15.15		
Post E-A Upgrade - FTR MW	20	200	93.1	10	323.1	148.1
Pre E-A Upgrade - FTR MW	0	80	95	0	175	
Post E-A Upgrade - FTR MW*CP	\$400	\$5,102	\$3,259	-\$152	\$8,609	\$3,243.20
Pre E-A Upgrade - FTR MW*CP	\$0	\$2,041	\$3,325	\$0	\$5,366	
Post C-B Upgrade - FTR MW	0	80	95	0	175	0
Pre C-B Upgrade - FTR MW	0	80	95	0	175	
Post C-B Upgrade - FTR MW*CP	\$0	\$2,041	\$3,325	\$0	\$5,366	\$0
Pre C-B Upgrade - FTR MW*CP	\$0	\$2,041	\$3,325	\$0	\$5,366	
Post E-D Upgrade - FTR MW	0	80	95	0	175	120
Pre E-D Upgrade - FTR MW	0	0	55	0	55	
Post E-D Upgrade - FTR MW*CP	\$0	\$2,041	\$3,325	\$0	\$5,366	\$3,440.80
Pre E-D Upgrade - FTR MW*CP	\$0	\$0	\$1,925	\$0	\$1,925	
Post A-D Upgrade - FTR MW	0	0	55	0	55	12
Pre A-D Upgrade - FTR MW	0	0	13	30	43	
Post A-D Upgrade - FTR MW*CP	\$0	\$0	\$1,925	\$0	\$1,925	\$1,924.50
Pre A-D Upgrade - FTR MW*CP	\$0	\$0	\$455	-\$455	\$1	

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## Compensation for Eligible Upgrades

Line	Auction Revenues due to Upgrade	Eligibility for IIARR Treatment	Payout
E-A Upgrade	\$3,243.20	50%	\$1,621.60
C-B Upgrade	\$0.00	50%	\$0.00
E-D Upgrade	\$3,440.80	25%	\$1,720.40
A-D Upgrade	\$1,924.50	25%	\$962.25

Since half of the value of the upgrade was settled in the Annual FTR Auction Example, half of the value of the upgrade is settled in the Monthly FTR Auction. Therefore the column titled "Eligibility for IIARR Treatment" reflects a 50% reduction from the "Transmission Line Upgrades" table on page 9.

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## Interim Incremental ARR Allocation Summary



### First Month's Compensation for Eligible Upgrades

<u>Line</u>	<u>Annual Auction Revenues due to Upgrade</u>	<u>Monthly Auction Revenues due to Upgrade</u>	<u>Payout</u>
E-A Upgrade	\$1,391.66	\$1,621.60	\$3,013.26
C-B Upgrade	\$0.00	\$0.00	\$0.00
E-D Upgrade	\$4,233.33	\$1,720.40	\$5,953.73
A-D Upgrade	\$3,119.33	\$962.25	\$4,081.58

Eligible IIARR Holders will not be charged for financial liabilities arising out of auction values that decrease as a result of an upgrade.



## Acknowledgements

To Dr. N. S. Rau for his tutelage in optimization theory.

To the PJM Interconnection for the five-bus power system model upon which this example is based.



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**Questions?**