

The background of the slide is a photograph of several high-voltage power transmission towers and their associated power lines. The towers are silhouetted against a bright blue sky filled with scattered white clouds. The perspective is from a low angle, looking up at the towers, which creates a sense of height and scale. The power lines stretch across the frame, converging towards the top.

PJM Market Efficiency Long Term Window Overview

September 16, 2016

- Overall Objectives
- Market Efficiency Selection Process Objective
- BC Numerical Example
- Examples Project Comparison
- Future Discussion Topics
- Appendix – References

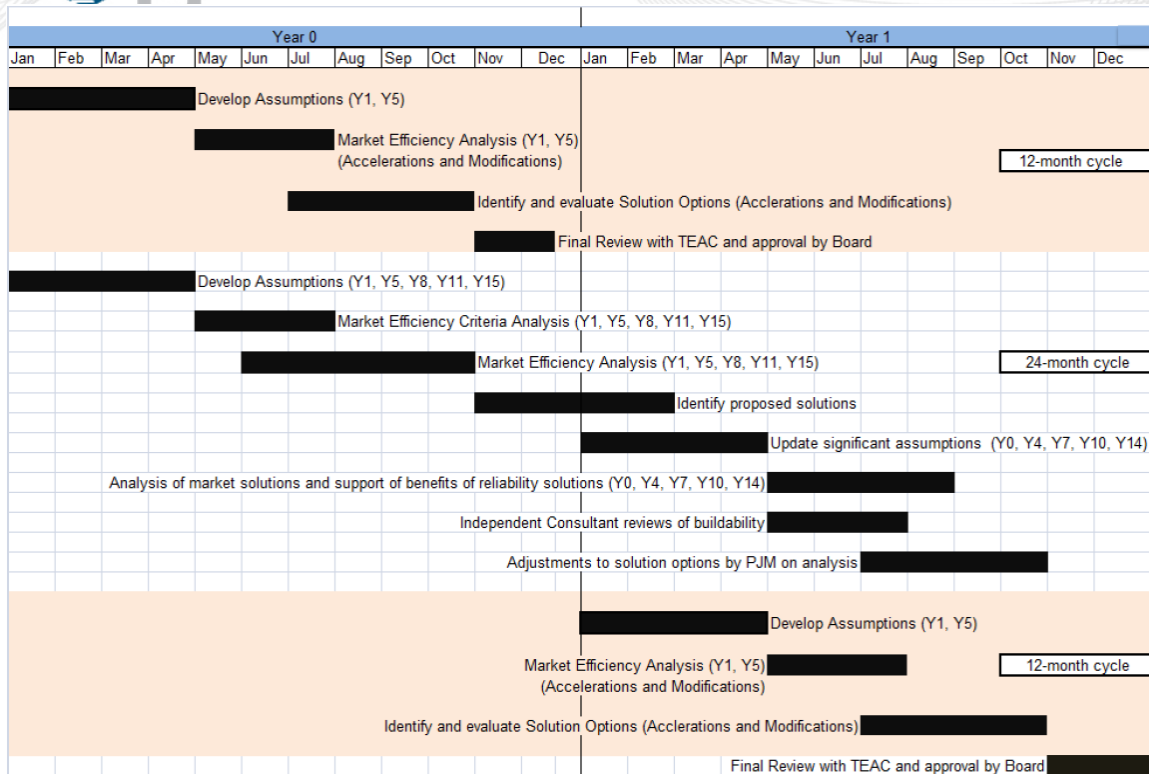
- Discuss PJM's Market Efficiency Selection Process
 - Concepts
 - Selection workflow diagram
 - Examples
- Discuss future education topics



Market Efficiency Selection Process Objective

- Objective is to approve overall most beneficial projects to relieve targeted PJM congestion
 - By evaluating project performance on:
 - Net Load Payments Benefits
 - Production Cost Benefits
 - Overall PJM Congestion Benefits
 - Other metrics considered by PJM
 - Considering the impact on reliability

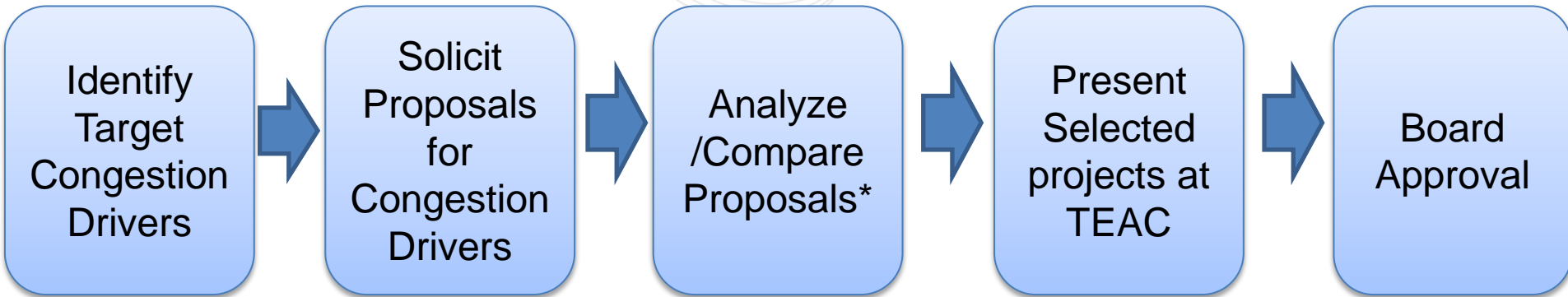
Market Efficiency Cycle Timeline



- 12 month
 - Acceleration

- 24 month Cycle
 - Input assumptions
 - Base case development
 - Develop target congestion
 - Proposal submission
 - Evaluation
 - Approval

Market Efficiency Process Overview



**Benefit/Cost Ratio at least 1.25 using the criteria as defined in Schedule 6, Section 1.5.7 of the PJM Operating Agreement and PJM Manual 14B, Attachment E.*



Market Efficiency Process – Identify Congestion Drivers

- **Historical Analysis**
 - PJM Market Monitor Annual Report
 - Historical analysis of real-time constraint
 - NERC Book of Flowgates
- **PROMOD simulations 2017, 2021, 2024, 2027**
 - Analyzed for congestion drivers



Market Efficiency Process – Proposals Solicitation

- Long Term Window: November through March
- Pre-qualification Process
- Registration Requirements
- Proposal Requirements



Market Efficiency Process – Proposal Analysis

- Each valid proposal is tested for Benefits/Cost > 1.25
 - Total Benefits = Energy Benefits + RPM Benefits
 - Energy Benefits
 - Regional Projects: 50% Change in Production Costs + 50% Change in Net Load Payments*
 - Lower Voltage Projects: 100% change in net load payments*
 - Reliability Pricing Model (RPM) Benefits
 - RPM Regional: 50% Change in Total System Capacity Cost + 50% Change in Load Capacity Payments
 - RPM for Lower Voltage Projects: 100% Change in Load Capacity Payments
- Candidates passing B/C tests:
 - Congestion driver reductions
 - Other factors: overall PJM congestion changes, PJM Load Payments, PJM Production Costs
 - Perform Sensitivities
 - Gas Sensitivity
 - Load Sensitivity
 - Other sensitivities as needed (Examples: gen exp, renewable penetration, carbon tax, imports/exports, etc.)

* Only zones with decrease in net load payments

- **Reliability Analysis**
 - Additional reliability upgrades
- **Independent Cost Analysis**
 - Projects exceeding \$50M Independent cost analysis
- **Constructability Analysis**
 - Verification of proposed schedule duration
 - Other risks to both cost and schedule
- **Project Combinations**
 - Combination of components of multiple projects
 - Incremental or multiple projects

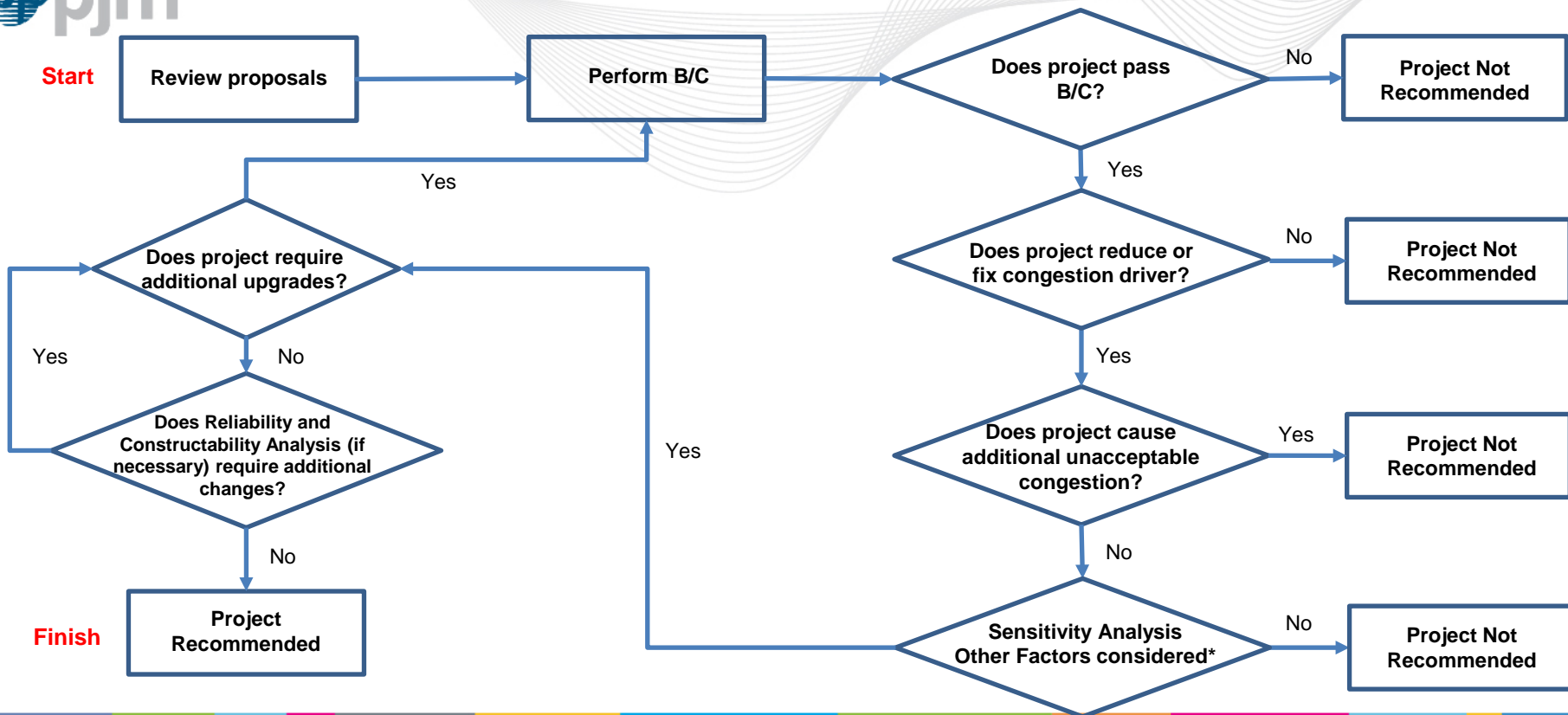


Market Efficiency Process – Approval & Communication

- Selected Market Efficiency projects require PJM board approval
- Approved projects are communicated at TEAC meetings
- Letter from PJM notifying construction responsibility

Example – Single Project

- Scenario Assumptions:
 - Base case + 2 sensitivities
- Project Assumptions:
 - Low Voltage Projects
 - Sub-regional congestion target
 - 1 Project Proposal receive for a particular congestion driver



* Other factors considered such as PJM Overall Production Cost, load Payments, and congestion



Project Benefits for Non-Simulated Years

Regional Transmission Expansion Plan Model year: 2021

Project In-service Year: 2021

Promod IV Simulation Years: 2017, 2021, 2024 & 2027



Period 1 benefits
2018 - 2020

$$2017 \text{ Benefit} + \frac{(2021 \text{ Benefit} - 2017 \text{ Benefit})}{2021 - 2017} \times (\text{year} - 2017)$$

Period 2 benefits
2022 - 2023

$$2021 \text{ Benefit} + \frac{(2024 \text{ Benefit} - 2021 \text{ Benefit})}{2024 - 2021} \times (\text{year} - 2021)$$

Period 3 benefits
2025 - 2026

$$2024 \text{ Benefit} + \frac{(2027 \text{ Benefit} - 2024 \text{ Benefit})}{2027 - 2024} \times (\text{year} - 2024)$$

Period 4 benefits

Excel Formula: trend (known y-values, known x-values, new x's)

e.g. trend ([2017, 2021, 2024, 2027 Energy Market Benefits], [2017, 2021, 2024, 2027 years], 2028)



Determining Revenue Requirement

Project Voltage: 500 kV or 230 kV **Project Cost:** \$110 Million Dollars **Project Benefit Period:** 15 yrs

PJM Fixed Carrying Charge Rate = 15.3% **PJM Discount Rate = 7.4%**

Project Annual Revenue Requirement = Project Cost x Fixed Carrying Charge Rate
= \$110 Million x 15.3% = \$16.83 Million Annually

Excel Formula: $p_v(\text{rate}, \# \text{ periods}, \text{payment per period})$

Net Present Value of Project Costs = $p_v(7.4\%, 15, -16.83) = \149 Million



Selecting Zones Based on Net Load Payment

The Project is not in-service until 2021. Therefore the benefits are evaluated between 2021 and 2035, the first 15 years of in-service life.

Zones 1, 2 and 4 all have Net Load Payment benefits with an NPV > 0 for the 15 year analysis period. These zones will be included in the total system benefit.

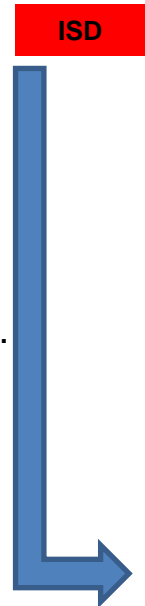
The Net Present Value of Net Load Payment Benefits in Zone 3 do not exceed zero for the 15 year analysis period. This zone will be excluded from the total system benefit calculation.

Low Voltage Project Net Load Payment Benefit

Zone 1 + Zone 2 + Zone 4 = \$223.85 Million

Regional Project Net Load Payment Benefit

50% (Zone 1 + Zone 2 + Zone 4) = \$111.92 Million



<u>Year</u>	<u>Zone 1</u>	<u>Zone 2</u>	<u>Zone 3</u>	<u>Zone 4</u>
2017	\$8.00	\$3.00	\$0.50	\$5.00
2018	\$9.00	\$2.50	\$0.40	\$5.30
2019	\$10.00	\$2.00	\$0.30	\$5.50
2020	\$11.00	\$1.50	\$0.20	\$5.80
2021	\$12.00	\$1.00	\$0.10	\$6.00
2022	\$12.30	\$1.30	(\$0.30)	\$6.70
2023	\$12.70	\$1.70	(\$0.60)	\$7.30
2024	\$13.00	\$2.00	(\$1.00)	\$8.00
2025	\$14.00	\$2.20	(\$1.70)	\$7.70
2026	\$15.00	\$2.30	(\$2.30)	\$7.30
2027	\$16.00	\$2.50	(\$3.00)	\$7.00
2028	\$16.60	\$2.00	(\$2.80)	\$7.90
2029	\$17.40	\$1.90	(\$3.20)	\$8.20
2030	\$18.20	\$1.90	(\$3.50)	\$8.40
2031	\$18.90	\$1.90	(\$3.80)	\$8.70
2032	\$19.68	\$1.84	(\$4.19)	\$8.90
2033	\$20.45	\$1.81	(\$4.53)	\$9.15
2034	\$21.21	\$1.78	(\$4.87)	\$9.40
<u>2035</u>	<u>\$21.97</u>	<u>\$1.75</u>	<u>(\$5.22)</u>	<u>\$9.64</u>
NPV (Millions)	\$138.97	\$16.17	(\$19.77)	\$68.71



System Adjusted Production Cost Benefits

- The Project is not in-service until 2021. Therefore the benefits are evaluated between 2021 and 2035
- NPV Adjusted Production Cost Benefit = NPV(7.4%, Adjusted Production Cost Savings)
- Regional Adjusted Production Cost Benefits = 50% x \$121.2 Million

<u>Year</u>	<u>Net Adjusted Production Cost Benefit</u>
2017	\$8.00
2018	\$8.50
2019	\$9.00
2020	\$9.50
ISD 2021	\$10.00
2022	\$10.70
2023	\$11.30
2024	\$12.00
2025	\$12.70
2026	\$13.30
2027	\$14.00
2028	\$14.50
2029	\$15.10
2030	\$15.70
2031	\$16.30
2032	\$16.88
2033	\$17.48
2034	\$18.08
<u>2035</u>	<u>\$18.68</u>
NPV (Millions)	\$121.2



Does Project Pass Criteria

- **REGIONAL METHOD**

- Total Energy Market Benefits = Load Payment Benefit x 50% + Production Cost Benefit x 50%
- Total Benefits = \$112 Million + \$60.6 Million = \$172.51 Million
- Does the Project Pass: Benefits / Costs = $\$172.51 / \$149 = 1.15 >$ **PROJECT FAILS**

- **Low Voltage Method**

- Total Benefits = 100% Load Payment Benefit = \$223.85 Million
- Does the Project Pass: Benefits / Costs = $\$223.85 / \$149 = 1.49 >$ **PROJECT PASSES**



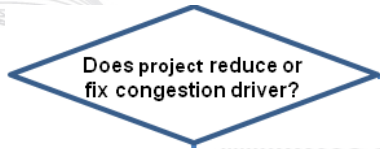
Examples – Single Proposal

- Example 1: The project BC ratio < 1.25
 - The project doesn't pass the BC ratio threshold in the base case.
 - Decision: The project is not selected.

	Proj01	
Sponsor	Sponsor 1	
Project Cost	\$80.00	
ISD	2021	
Delta Congestion - Congestion Driver	\$ (30.00)	
B/C Ratio Base Case	1.24	FAIL

- Example 2: The project BC ratio ≥ 1.25
 - The project passes the BC ratio threshold in the base case.
 - Decision: The project is selected for further analysis.

	Proj01	
Sponsor	Sponsor 1	
Project Cost	\$80.00	
ISD	2021	
Delta Congestion - Congestion Driver	\$ (35.00)	
B/C Ratio Base Case	1.25	PASS



Examples – Single Proposal (cont.)

- Example 3: The project BC ratio ≥ 1.25 and does not reduce the congestion driver

- The project doesn't decrease the congestion driver.
- Decision: The project is not selected.

	Proj01
Sponsor	Sponsor 1
Project Cost	\$80.00
ISD	2021
Delta Congestion - Congestion Driver	\$0
B/C Ratio Base Case	1.25

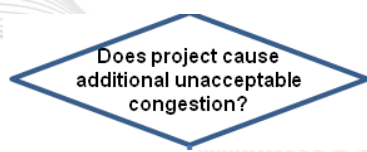
FAIL

- Example 4: The project BC ratio ≥ 1.25 and reduces the congestion driver

- The project passes the BC ratio threshold in the base case and it decreases the congestion driver.
- Decision: The project is selected for further analysis.

	Proj01
Sponsor	Sponsor 1
Project Cost	\$80.00
ISD	2021
Delta Congestion - Congestion Driver	\$ (30.00)
B/C Ratio Base Case	1.35

PASS



Examples – Single Proposal (cont.)

- **Example 5: The project causes unacceptable congestion.**

- The project passes the BC ratio threshold in the base case.
- The project decreases the congestion driver.
- The project causes unacceptable congestion on other facilities.
- Decision: The project is not selected as submitted.

Additional market efficiency upgrades to address additional congestion may be considered.

To be approved the project with upgrades must pass the BC threshold.

	Proj01
Sponsor	Sponsor 1
Project Cost	\$80.00
ISD	2021
Delta Congestion - Congestion Driver	\$ (30)
Delta PJM Total Congestion	\$ 35
B/C Ratio Base Case	1.25

**Increase
FAIL**

- **Example 6: The project does not cause unacceptable congestion.**

- The project passes the BC ratio threshold in the base case.
- The project decreases the congestion driver.
- The project does not cause unacceptable congestion on other facilities.
- Decision: The project is selected for further analysis.

	Proj01
Sponsor	Sponsor 1
Project Cost	\$80.00
ISD	2021
Delta Congestion - Congestion Driver	\$ (30)
Delta PJM Total Congestion	\$ (10)
B/C Ratio Base Case	1.45

PASS

Examples – Single Proposal (cont.)

- **Example 7: The project fails on one or more sensitivities.**
 - The project passes the BC ratio threshold in the base case.
 - The project decreases the congestion driver.
 - The project does not cause unacceptable congestion on other facilities.
 - The project fails on one or more sensitivities.
 - Decision: The project is not selected.

	Proj01
Sponsor	Sponsor 1
Project Cost	\$80.00
ISD	2021
Delta Congestion - Congestion Driver	\$ (30)
Delta PJM Total Congestion	\$ (10)
B/C Ratio Base Case	1.25
B/C Ratio base Sensitivity 1	2.05
B/C Ratio base Sensitivity 2	1.24

FAIL

- **Example 8: The project passes the BC ratio threshold in all sensitivities.**
 - The project passes the BC ratio threshold in the base case.
 - The project decreases the congestion driver.
 - The project does not cause unacceptable congestion on other facilities.
 - The project passes the BC ratio threshold in all sensitivities.
 - Decision: The project is selected for further analysis.

	Proj01
Sponsor	Sponsor 1
Project Cost	\$80.00
ISD	2021
Delta Congestion - Congestion Driver	\$ (30)
Delta PJM Total Congestion	\$ (10)
B/C Ratio Base Case	1.25
B/C Ratio base Sensitivity 1	2.05
B/C Ratio base Sensitivity 2	1.25

PASS



Examples – Single Proposal (cont.)

- Example 9: The project requires additional upgrades.
 - The project passes all the previous tests: BC ratio threshold in the base, and sensitivity cases, decreases the congestion driver, and it does not create unacceptable additional congestion.
 - However the project requires additional reliability upgrades.
 - Decision: The cost of the project is increased with the cost of the upgrades. The project with the upgrades must pass the BC ratio threshold in the base, and sensitivity cases, it should decrease the congestion driver, and it should not create unacceptable additional congestion.

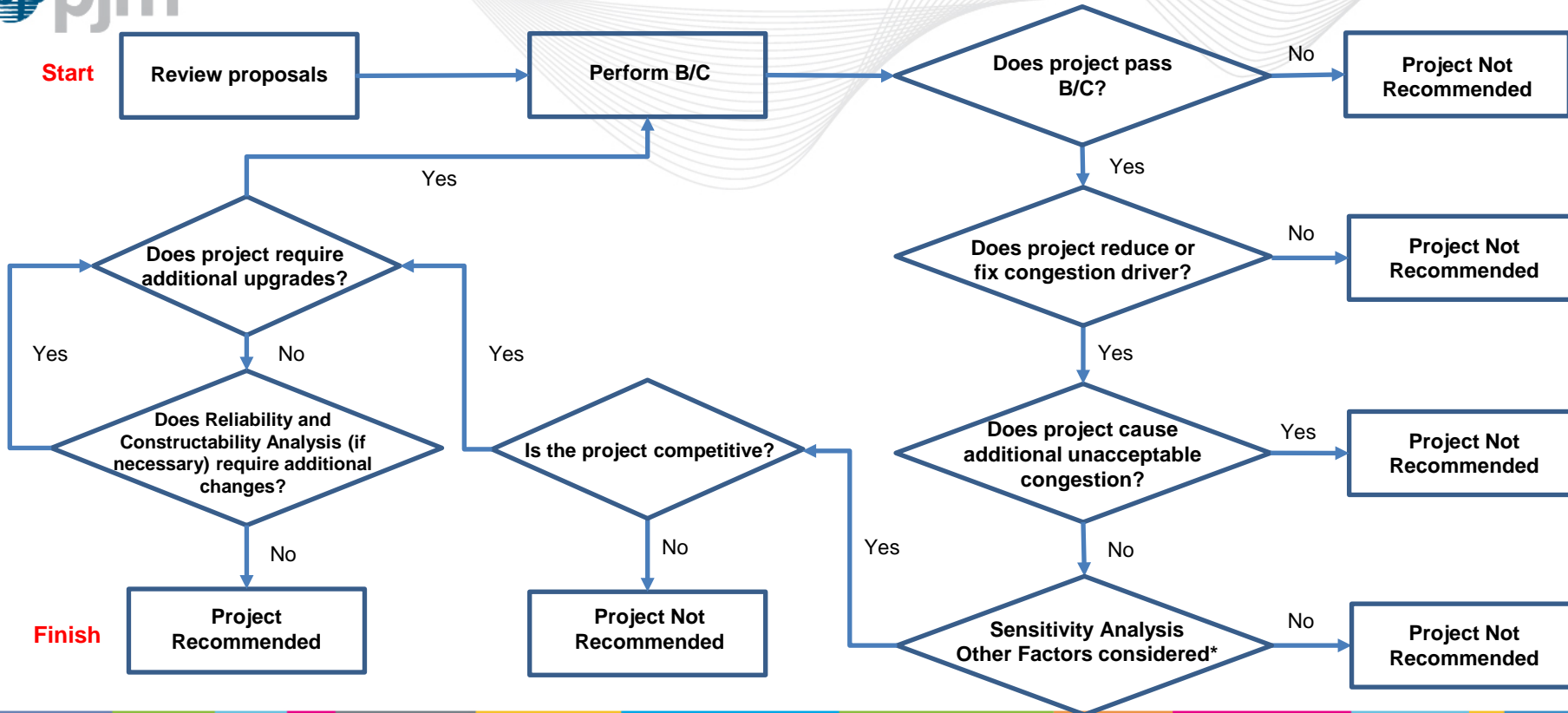
	Proj01
Sponsor	Sponsor 1
Project Cost with upgrades	\$100.00
ISD	2021
Delta Congestion - Congestion Driver	\$ (50)
Delta PJM Total Congestion	\$ (30)
B/C Ratio Base Case	1.25
B/C Ratio base Sensitivity 1	1.75
B/C Ratio base Sensitivity 2	1.26

Increase

PASS

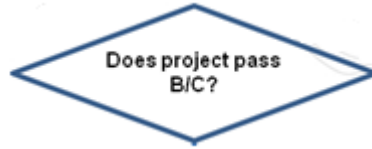
- Example 10: The project does not require additional upgrades.
 - Decision: The project is selected to be recommended for approval.

Examples – Multiple Proposals



* Other factors considered such as PJM Overall Production Cost, load Payments, and congestion

- Scenario Assumptions:
 - Base case + 2 sensitivities
- Project Assumptions:
 - Low Voltage Projects
 - Sub-regional congestion target
 - 2 Project Proposals



- Example 1: Some projects have BC ratios < 1.25
 - Decision: The projects that pass the BC ratio threshold are selected for further analysis.
 - The projects that don't pass the BC ratio threshold in the base case are discarded.

	Proj01	Proj02	
Sponsor	Sponsor 1	Sponsor 2	
Project Cost	\$80.00	\$100.00	
ISD	2021	2021	
Delta Congestion - Congestion Driver	\$ (30)	\$ (35)	
B/C Ratio Base Case	1.25	1.24	FAIL

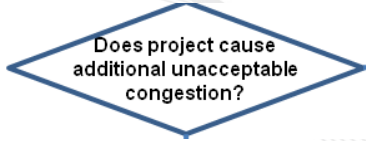
Does project reduce or fix congestion driver?

- Example 2: Some projects do not reduce the congestion driver

- At this step, all projects pass the BC ratio threshold.
- Some projects do not address the congestion driver.
- Decision: The projects that reduce the congestion driver are selected for further analysis.

The projects that don't reduce the congestion driver are discarded.

	Proj01	Proj02
Sponsor	Sponsor 1	Sponsor 2
Project Cost	\$80.00	\$100.00
ISD	2021	2021
Delta Congestion - Congestion Driver	\$ (50)	\$ 5 FAIL
B/C Ratio Base Case	1.35	1.27



- **Example 3: Some projects cause unacceptable congestion.**
 - At this step, all projects pass the BC ratio threshold in the base case, and decrease the congestion driver.
 - Some projects cause unacceptable congestion on other facilities.
 - Decision: For the projects that cause unacceptable congestion, additional market efficiency upgrades to address additional congestion may be considered.

To be considered for further analysis, the projects with their corresponding additional upgrades must pass the BC threshold, and decrease the congestion driver.

The projects that don't create additional unacceptable congestion go straight to the next step.

	Proj01	Proj02
Sponsor	Sponsor 1	Sponsor 2
Project Cost	\$80.00	\$100.00
ISD	2021	2021
Delta Congestion - Congestion Driver	\$ (40.00)	\$ (45.00)
Delta PJM Total Congestion	\$ 45	\$ (20)
B/C Ratio Base Case	1.35	1.28

Examples – Multiple Proposal (cont.)

- **Example 4: Some projects fail on one or more sensitivities.**
 - At this step, all projects pass the BC ratio threshold in the base case, decrease the congestion driver, and don't cause unacceptable congestion on other facilities..
 - Some projects fail on one or more sensitivities.
 - Decision: The projects that fail the BC ratio threshold on one or more sensitivities are discarded..
- The projects that pass all sensitivities go straight to the next step.

	Proj01	Proj02
Sponsor	Sponsor 1	Sponsor 2
Project Cost	\$80.00	\$100.00
ISD	2021	2021
Delta Congestion - Congestion Driver	\$ (40.00)	\$ (45.00)
Delta PJM Total Congestion	\$ (10)	\$ (20)
B/C Ratio Base Case	1.35	1.28
B/C Ratio base Sensitivity 1	2.3	2.54
B/C Ratio base Sensitivity 2	1.25	1.24

FAIL



Examples – Multiple Proposal (cont.)

- Example 5: Some projects don't pass the BC ratio threshold after the upgrades

	Proj01	Proj02
Sponsor	Sponsor 1	Sponsor 2
Project Cost	\$80.00	\$100.00
Required Upgrades Cost	\$30.00	\$20.00
Total Project Cost with Upgrades	\$110.00	\$100.00
ISD	2021	2021
Delta Congestion- Congestion Driver	(\$20)	(\$30)
B/C Ratio Base Case	1.2	1.25

- Example 6: Some projects don't pass the BC threshold after the cost review

	Proj01	Proj02
Sponsor	Sponsor 1	Sponsor 2
Project Cost	\$80.00	\$100.00
Reviewed Cost	\$110.00	\$100.00
ISD	2021	2021
Delta Congestion- Congestion Driver	(\$10)	(\$30)
B/C Ratio base Case	1.2	1.25

- Continue Hypothetical Examples – Comparing Projects
- Project Selections Regional Metric
- Begin Guidelines Discussion

Appendix 1 – Operating Agreement & Manual References

- Scope, PJM requirements & Member requirements
- <http://www.pjm.com/about-pjm/member-services.aspx>
- PJM Manual 14B, Section 2.6:
<http://www.pjm.com/~media/documents/manuals/m14b.ashx>
- PJM Operating Agreement, Schedule 6, Section 1.5.7:
<http://www.pjm.com/media/documents/merged-tariffs/oa.pdf>
- PJM Market Efficiency Practices <http://www.pjm.com/~media/planning/rtep-dev/market-efficiency/pjm-market-efficiency-modeling-practices.ashx>