PNM 2023-2042 IRP: Transmission

STEERING MEETING #6

OCTOBER 6, 2022

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MEETING GROUND RULES

THE FOCUS OF THE MEETING IS THE DEVELOPMENT OF THE 2023 IRP

01

- Questions and comments are welcome – One Person Speaks at a Time

02

- Reminder; today's presentation is not PNM's plan or a financial forecast, it is an illustration of the IRP process

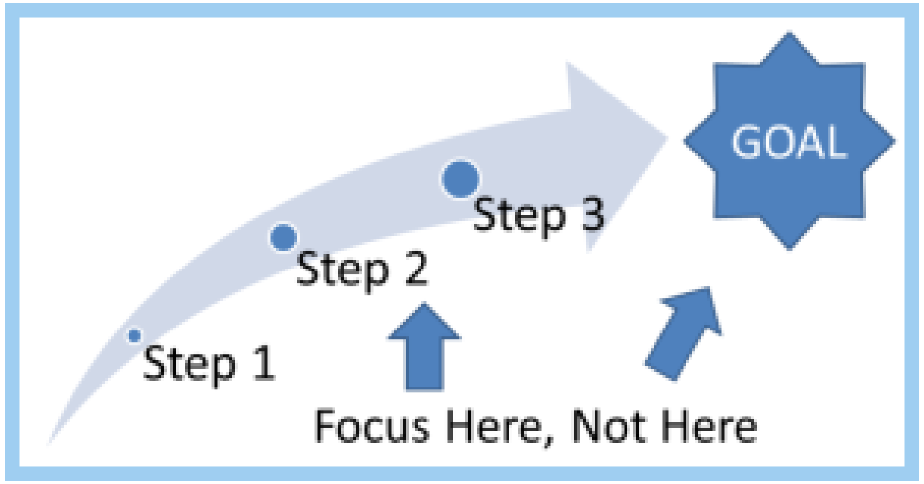
03

- When asking a question, please speak clearly and slowly as all questions will be logged and labeled with the person and organization responsible for asking the question

04

- These meetings are about the 2023 IRP, questions and comments should relate to this IRP. Any questions or comments related to other regulator proceedings should be directed towards the specific filing.

THE FOCUS OF THE MEETING IS THE DEVELOPMENT OF THE 2023 IRP



The technical sessions are about discussing the advantages and disadvantages regarding the application of different technical methodologies within the IRP modeling framework.

We are not here to focus on the results or drive towards a specific result. **We all know where we are going: 100% Carbon Free by 2040. The focus in the IRP development is how do we get there in the best way possible for PNM's customers and New Mexico.**

AGENDA

PNM Transmission Engineering

- Transmission System Overview
- Role of Transmission in Energy Transition
- PNM's Transmission System and Capability
- Transmission - Regulatory Construct
- The Transmission/Generation Challenge
- Transmission Strategy Going Forward
- Transmission in IRP

E3

- Transmission in Utility Integrated Resource Planning

PNM Integrated Resource Planning and transmission teams

- PNM Transmission Modeling for IRP – 2020 & 2023
- Nodal Transmission Modeling

Transmission in Integrated Resource Planning

Presentation to PNM IRP Workshop

October 6, 2022

Energy+Environmental Economics

Nick Schlag, Partner

Emerging need for consideration of transmission in resource planning efforts

- **Utility resource planning and transmission planning have historically been separate processes under traditional planning paradigm**
- **The industry's shift towards variable renewables is an increasing driver of the need for new transmission development and has prompted utilities to increasingly consider how transmission system needs affect their resource decisions**
- **Questions addressed in this presentation:**
  1. How do transmission analysis in IRPs compare with transmission planning studies?
  2. What are the methodologies being used by utilities to account for potential transmission expansion and the associated costs in development of future portfolios?

Conceptual transmission projects identified to deliver renewable resources to load in California's Renewable Energy Transmission Initiative (2009)

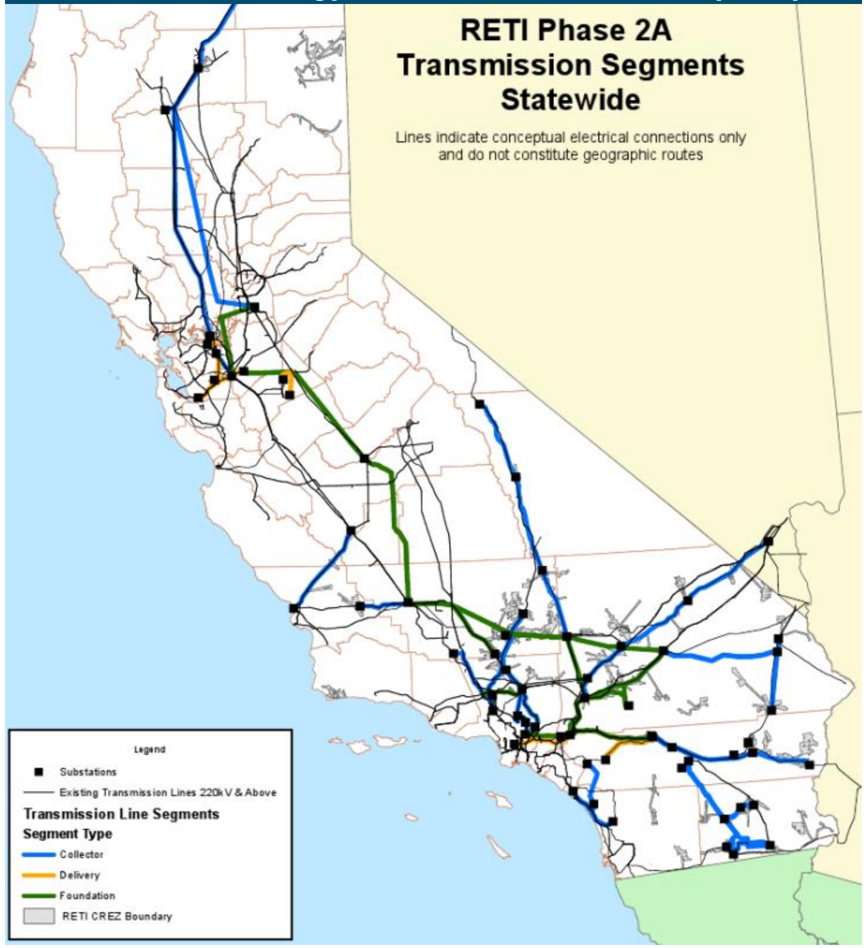


Image Source: Renewable Energy Transmission Initiative Phase 2A Final Report

Transmission in IRPs vs. Transmission Planning

Transmission Analysis in IRPs

- Transmission analysis in IRPs are typically performed under a ZONAL (pipe and bubble) modeling framework
- Purpose of the analysis is to ensure resource selection reflects the attendant needs of the transmission system and to allow evaluation of remote resources coupled with transmission expansion as an option – not to directly inform transmission investment decisions

Transmission Planning Studies

- More detailed NODAL analysis is typically conducted in utilities' transmission planning processes, including detailed resource deliverability study, nodal production cost modeling, and power flow analysis, to support direct resource interconnection and transmission investment decisions

Increased momentum to bring the two ends of the spectrum together and connect the two planning processes (e.g. under the concept of "Integrated System Planning"), however, the concept is still in early-development stage

Three general approaches for incorporating transmission in resource selection & portfolio development in IRPs

All under a zonal modeling framework, with Increasing Complexity

1. "CREZ"-style cost adders applied to resources or locations

Methodology: Generic transmission assumptions used to develop cost adders that are applied to resources in capacity expansion modeling
Examples: PNM, El Paso Electric, PSE, PGE

2. Scenario analysis of transmission projects

Methodology: Scenarios with and without certain transmission projects are analyzed in resource planning analysis, which allows the planners to compare the benefits and costs associated with those transmission projects
Examples: PacifiCorp, NV Energy, Nova Scotia Power, Idaho Power

3. Co-optimization of generation & transmission expansion under zonal system representation

Methodology: Potential transmission upgrade and expansion are characterized as candidate new build options which increase transmission capability between zones with estimated costs in capacity expansion models; resource and transmission expansion are co-optimized in the modeling process
Examples: PacifiCorp, Nova Scotia Power

Use of transmission cost adders is the most common approach to including transmission in IRPs

Utility	Cost Adders	Scenario Analysis	Full Co-optimization
Avista Corporation	✓	✗	✗
California Public Utility Commission	✓	✗	✗
El Paso Electric	✓	✗	✗
Idaho Power	✓	✓	
Nova Scotia Power	✗	✓	✓
NV Energy	✗	✓	✗
PacifiCorp	✗	✓	✓
Portland General Electric	✓	✗	✗
Public Service Company of New Mexico	✓	✗	✗
Puget Sound Energy	✓	✗	✗
Sacramento Municipal Utility District	✓	✗	✗
Xcel Colorado	✓	✗	✗

Inclusion of cost adders for transmission necessary to deliver new resources common across IRPs

- **Transmission cost adders applied to resources allow planners to account for costs of transmission in addition to generation resources in the resource selection process**
  - Cost adders may either be resource-specific or location-specific (as in Texas's "Competitive Renewable Energy Zones" (CREZs) or California's RETI process)
  - While costs of transmission are included in resource selection and total cost metrics, the underlying transmission system is often not represented explicitly in the model

- **Data sources used to inform cost adders drawn from a variety of sources:**
  - Utility Open Access Transmission Tariff (OATT) rates
  - Project-specific transmission cost estimates
  - Generic transmission cost assumptions ($/mile)

Example of CREZ-style cost adders in EPE 2020 IRP

Figure 3-10. Renewable Energy Zones and Transmission Expansion Options

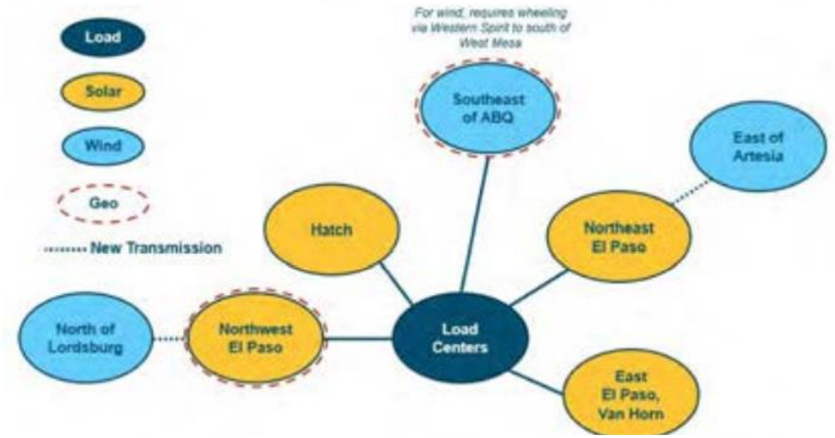


Table 3-7. Transmission Upgrade Costs for Candidate Renewable Resources

Transmission Zone	Downstream Transmission Zone	Assumed Available Capacity Before Upgrades (MW)	Upgrade Length (miles)	Upgrade Voltage (kV)	Upgrade cost ($/kW-yr)[30]
Load Centers	n/a	150	n/a	n/a	n/a
Northeast El Paso	Load Centers	100	75	115	$22.5
East El Paso	Load Centers	100	40	115	$22.5
Van Horn	Load Centers	40	120	115	$30.7
Hatch	Load Centers	40	25	115	$30.7
Northwest El Paso	Load Centers	200	55	345	$55.5
North of Lordsburg	Northwest El Paso	0	50	345	$41.5
East of Artesia	Northeast El Paso	0	200	345	$56.9
Southeast of ABQ[31]	Load Centers	300	125	345	$65.4

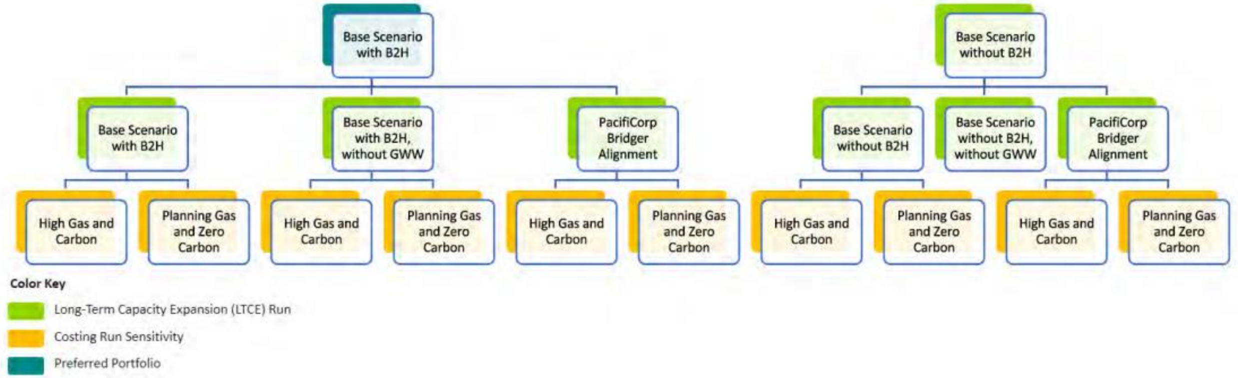
Other examples of transmission cost adders in IRPs : PGE 2019 IRP, PSE 2021 IRP, CPUC 2019-2020 IRP, Avista 2021 IRP, SMUD 2019 IRP, Xcel Colorado 2021 ERP

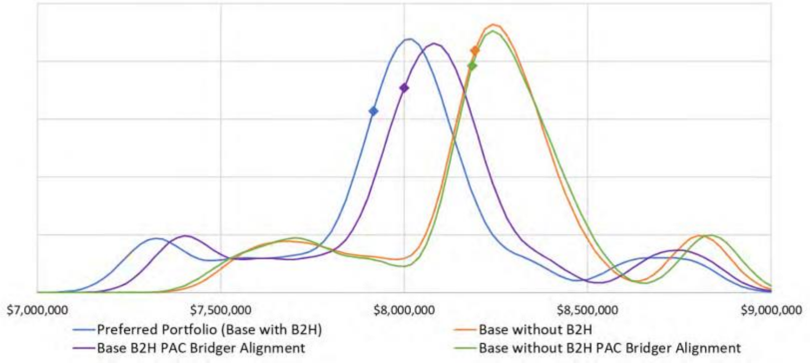
Scenario analysis used to evaluate targeted transmission expansion strategies

- **Scenario analysis is used in multiple utilities' IRPs to evaluate the benefits and costs of certain strategic transmission projects**
  - Scenarios typically designed surrounding key strategic projects under consideration
  - Allows for detailed examination of the benefits and costs associated with the projects and supports development of action items related to the specific projects of focus
  - Typically coupled with other modeling techniques (e.g. cost adders) to allow better consideration of longer-term generic transmission expansion options

- **Idaho Powe's 2021 IRP analyzed a comprehensive set of scenarios surrounding two strategic transmission projects – Boardman to Hemingway (B2H) and Gateway West**
  - The analysis demonstrated significant value provided by B2H and identified it as part of the preferred portfolio

Example of transmission scenario analysis in IPC 2021 IRP





Other examples of scenario analysis of transmission expansion: PacifiCorp 2021 IRP, NV Energy 2020 IRP, Nova Scotia Power 2020 IRP

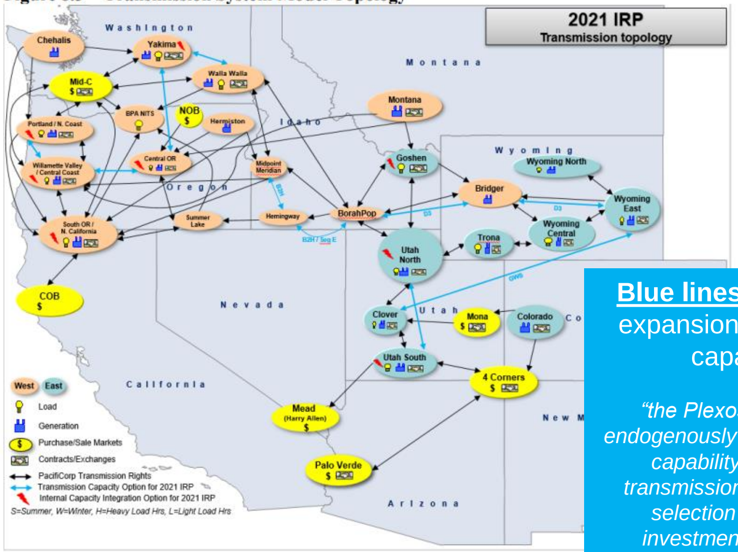
Co-optimization of generation and transmission performed under specific circumstances

+ **PacifiCorp's 2020 IRP uses a detailed approach to modeling transmission that reflects unique aspects of its system (service territory spread across six states and an existing portfolio of resources far from major load centers)**
  - New transmission options capable of increasing transmission capability across zones are characterized in the model and co-optimized with resource expansion
  - Sensitivity analysis layered on top to study the value of several major transmission projects, including the Boardman-to-Hemingway and Gateway South transmission segments

+ **Preferred portfolio identified through the IRP analysis includes detailed transmission investments associated with resource expansion plans; targeted near-term actions developed to facilitate the development of transmission projects identified in preferred portfolio**

Example of Co-optimized modeling in PAC 2020 IRP

Figure 8.3 – Transmission System Model Topology



Blue lines indicate transmission expansion options considered in capacity expansion:

"the Plexos model had the ability to endogenously view costs and transmission capability associated with certain transmission upgrades that allowed for selection of specific transmission investments that coincide with new resource additions"

Table 1.1 – Transmission Projects Included in the 2021 IRP Preferred Portfolio[1,2,*]

Year	Resource(s)	From	To	Description
2025	1,641 MW RFP Wind (2025)	Aeolus WY	Clover	Enables 1,930 MW of interconnection with 1700 MW of TTC: Energy Gateway South
2026	615 MW Wind (2026)	Within Willamette Valley OR Transmission Area		Enables 615 MW of interconnection: Albany OR area reinforcement
2026	130 MW Wind (2026) 450 MW Wind (2032) 650 MW Battery (2037)	Portland North Coast	Willamette Valley Southern Oregon	Enables 2080 MW of interconnection with 1950 MW TTC; Portland Coast area reinforcement, Willamette Valley and Southern Oregon
2026	600 MW Solar+Storage (2026)	Borah-Populous	Hemingway	Enables 600 MW of interconnection with 600 MW of TTC: B2H Boardman-Hemingway
2028	41 MW Solar+Storage (2028) 377 MW Solar+Storage (2030)	Within Southern OR Transmission Area		Enables 460 MW of interconnection: Medford area reinforcement
2030	160 MW Solar+Wind+Storage (2030) 20 MW Solar+Storage (2030)	Yakima WA Transmission Area		Enables 180 MW of interconnection: Yakima local area reinforcement
2031	820 MW Solar+Storage (2031) 206 MW Non-Emitting Peaker (2033)	Northern UT Transmission Area		Enables 1040 MW of interconnection: Northern UT 345 kV reinforcement
2033	400 MW Non-Emitting Peaker (2033) 1100 MW Solar+Storage (2033)	Southern UT	Northern UT	Enables 1500 MW of interconnection with 800 MW TTC: Spanish Fork - Mercer 345 kV; New Emery – Clover 345 kV
2040	156 MW Solar+Storage (2040) 500 MW Pumped Storage (2040)	Central OR	Willamette Valley	Enables 980 MW of interconnection with 1500 MW of TTC

Tradeoffs among transmission modeling approaches

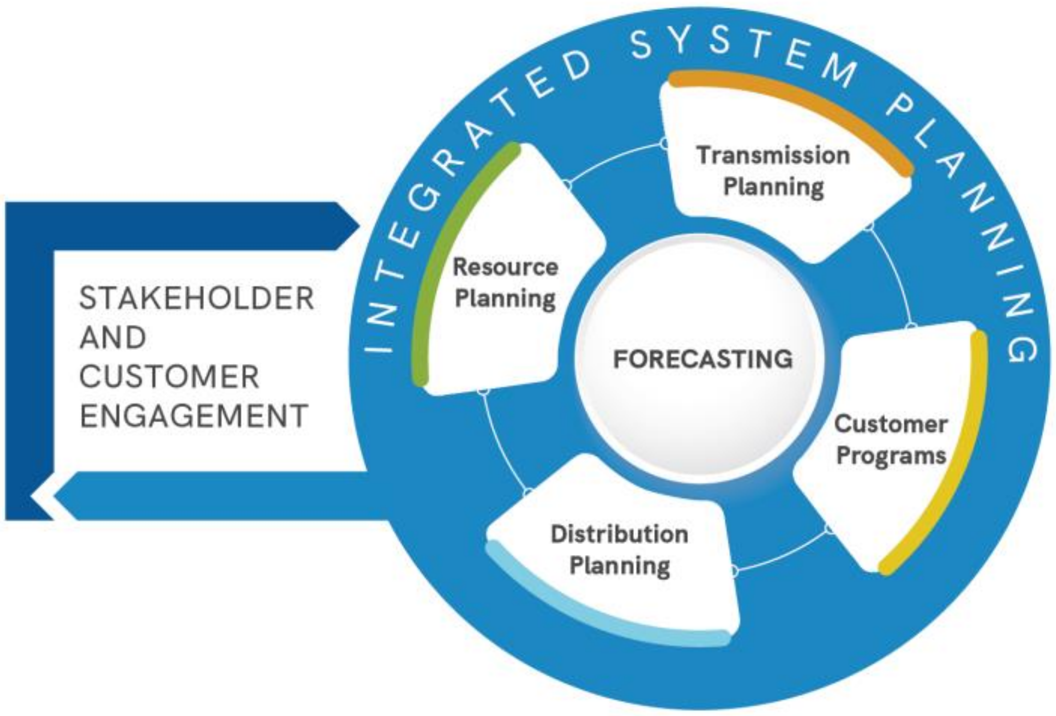
+ **All three methods allow for consideration of transmission costs associated with new resources and essentially provides a framework that allows utilities to evaluate remote resources coupled with potential transmission expansion as an option/strategy in resource planning processes, with different pros and cons:**

Methodology	Advantages	Limitations
Cost Adders	• Can easily be incorporated into any capacity expansion model	• Difficult to capture "lumpiness" of new transmission investments • Only suitable for transmission whose primary benefit is the delivery of new resources to loads
Scenario Analysis	• Provides an explicit quantification of the benefits of a specific project (or set of projects)	• Puts pressure on scenario design to identify the right set of options to study • Difficult to examine generic long-term transmission options when used alone
Co-optimization of Generation and Transmission (under zonal representation)	• Allows for better characterization of resource competition of transmission capacity within a zone and the "lumpiness" of new transmission investments	• Computationally complex to implement; not compatible with all capacity expansion models • Subject to knife-edge effects

Integrated System Planning: the next frontier of coordinated generation & transmission planning?

- **The concept of integrated "system" planning is gaining momentum at a number of utilities**
- **ISP represents a coordinated planning effort that unites multiple planning functions within a utility in a single analytical process**
  - Involves iterative modeling processes and information sharing among groups
- **Multiple utilities have recently commenced their first Integrated System Planning processes:**
  - Salt River Project (Integrated System Plan)
  - Duke Energy (Integrated System & Operations Planning)
  - Hawaiian Electric Company (Integrated Grid Planning)

SRP's Integrated System Planning Framework



Transmission Modeling for PNM IRP

Nick Phillips

Tom Duane

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PROGRESSION OF TRANSMISSION MODELING IN IRP

2011 IRP

- Modeled interconnection and minimal delivery costs for candidate resources (EPRI)

2014 IRP

- Modeled interconnection and minimal delivery costs for candidate resources (EPRI)
- Included wheeling costs for potential market Combined Cycle

2017 IRP

- Modeled interconnection and delivery costs for candidate resources
- Technology specific interconnection and delivery costs refined and included in new resource capital costs (EPRI)

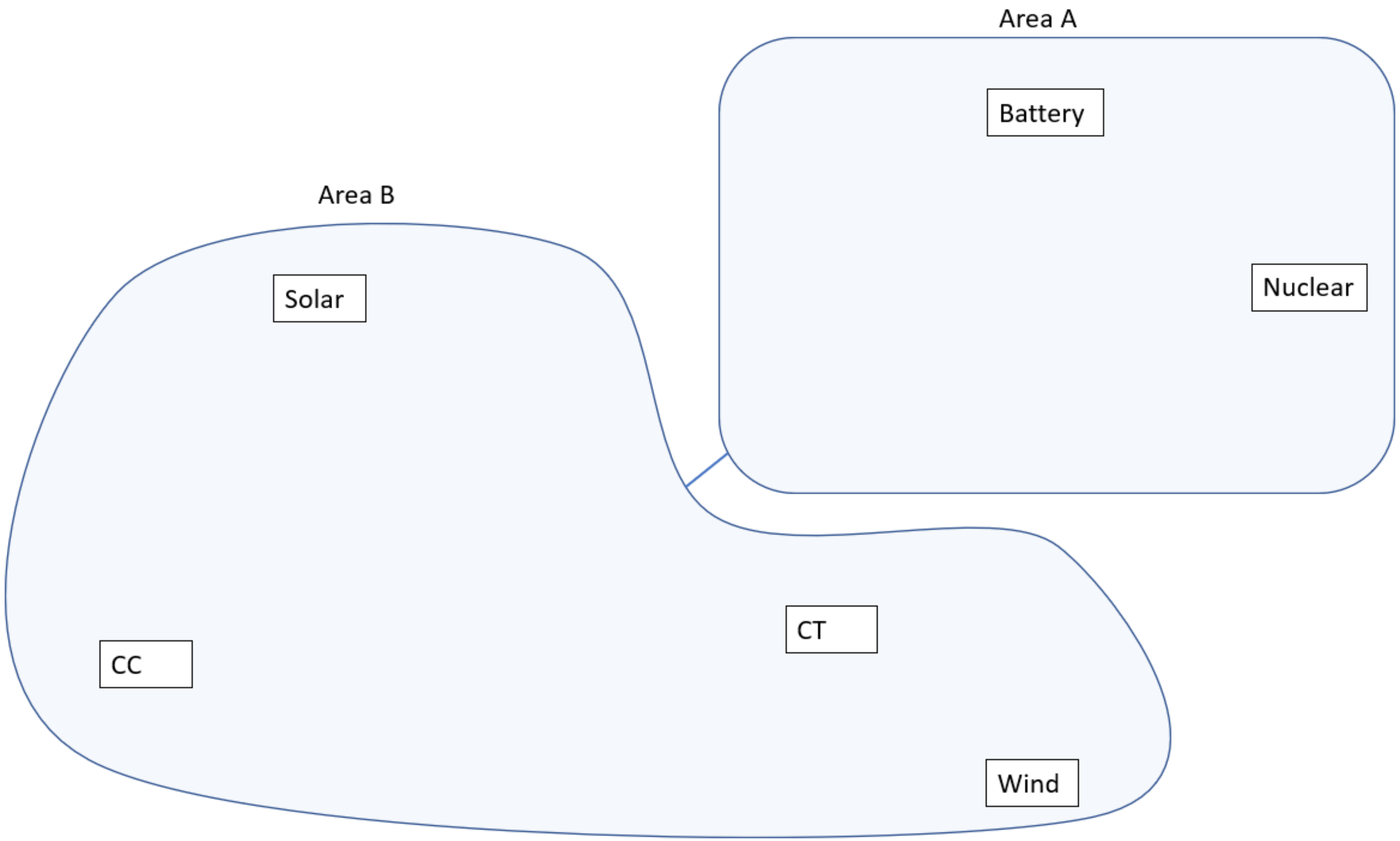
2020 IRP

- Modeled interconnection and delivery costs for candidate resources (EIA, NREL, PNM)
- Proof of concept zonal transmission modeling efforts with potential transmission projects
- Final modeling incorporated transmission cost adders to candidate resources

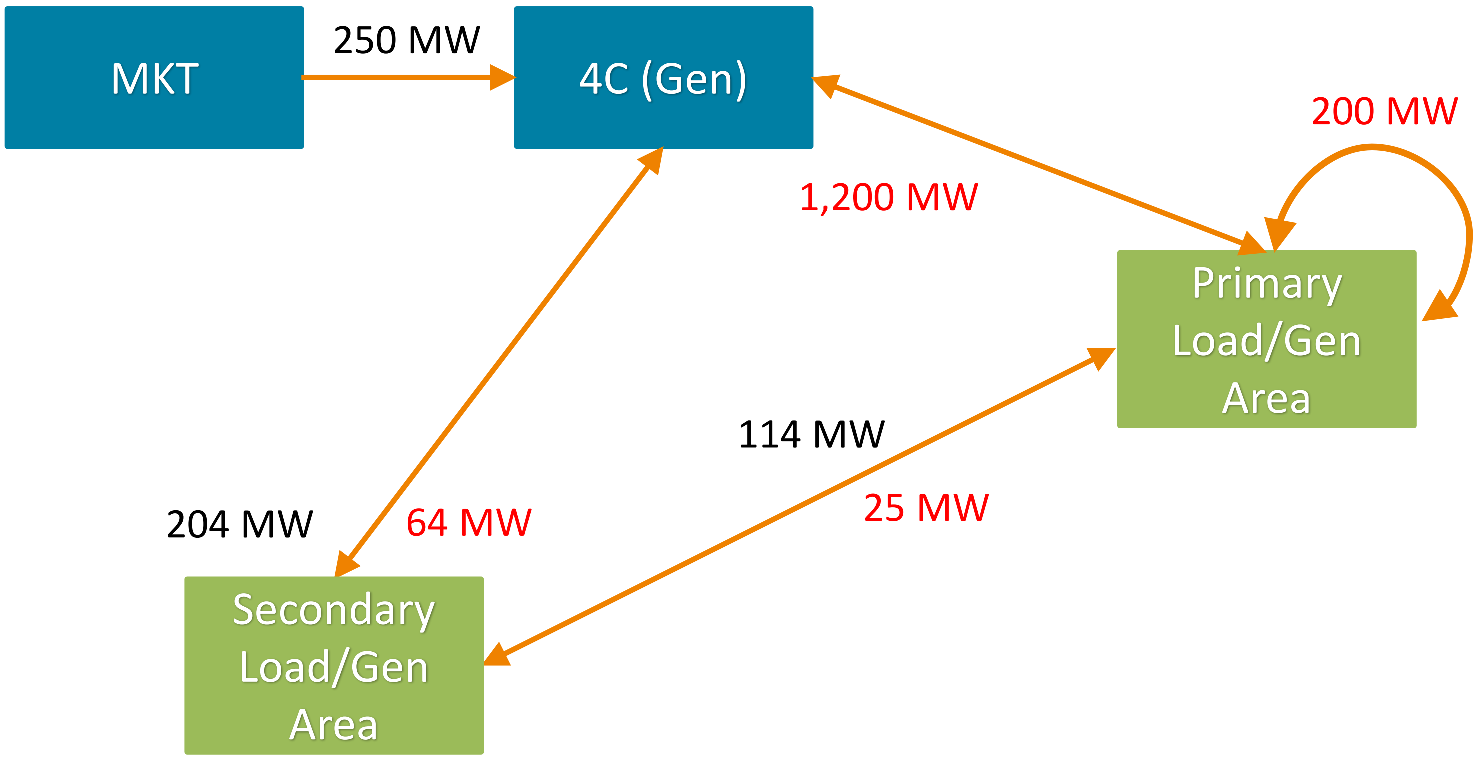
ZONAL TRANSMISSION MODELING OVERVIEW

Zonal (pipe and bubble)

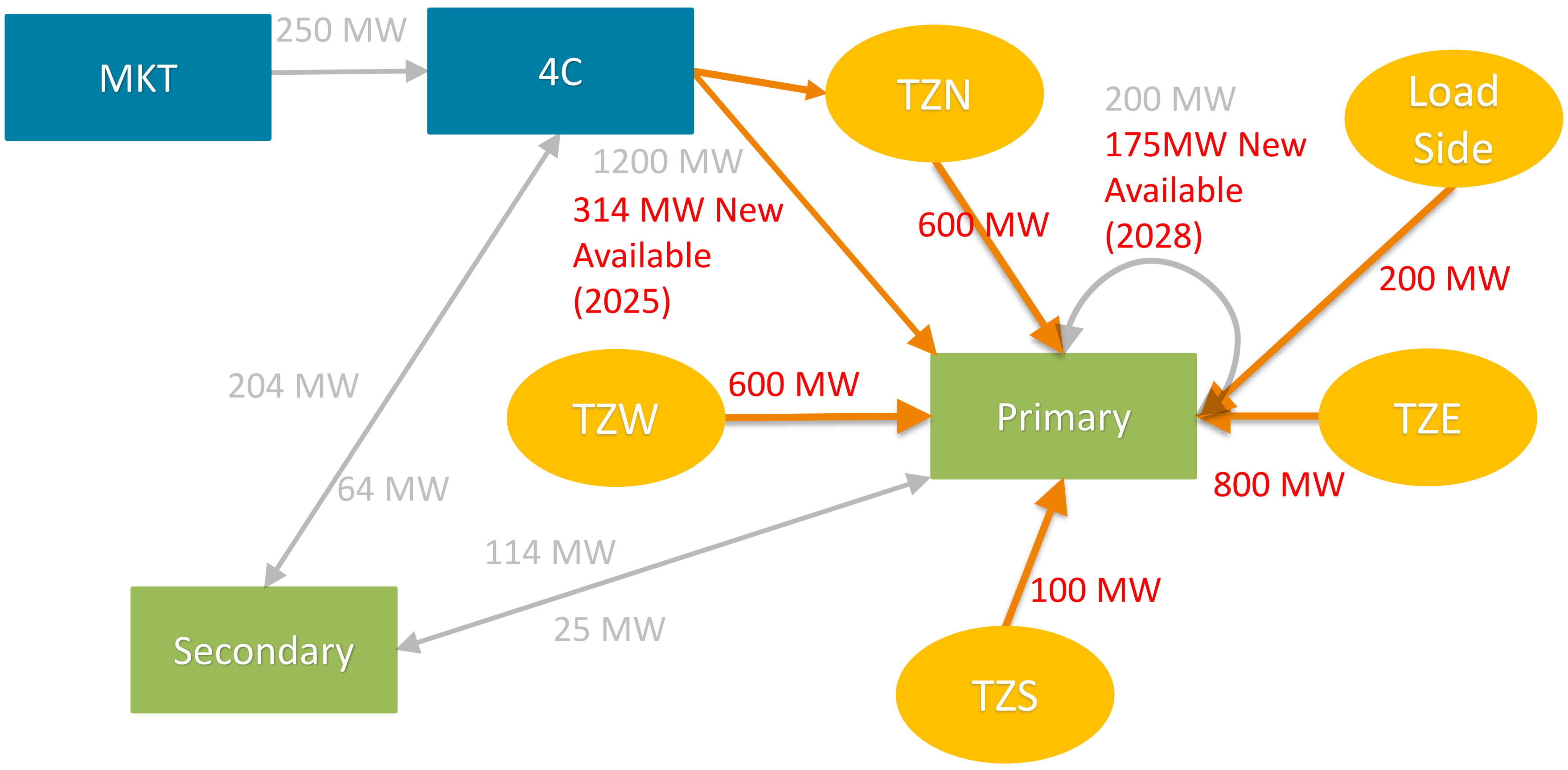
- Portfolio optimization
- Simulating transmission capacity limits and costs
- Environmental compliance
- Long-term study periods (1-20 yrs)



2020 IRP TOPOLOGY – CORE SYSTEM



2020 IRP TOPOLOGY – ZONAL MODELING



2020 IRP TRANSMISSION MODELING EFFORTS

Initial Modeled Topology

- Developed Transmission Expansion Projects Based on PNM Transmission Estimates
- New Generic Resources Added After its Associated Transmission Line is Added
- All Generic Resources Duplicated in Each Area (Except Wind and Pumped Storage)

Pros: More Accurate Transmission Expansion, Shows the "Lumpiness" of Transmission Buildout, Allows for More Efficient Use of Transmission (Solar + Storage)

Cons: Expansion Plan Execution Time ~5X Longer, Transmission Expansion is Limited to Known Options, Could be Less Accurate for Later Years

Final Modeled Topology

- Transmission Costs Modeled Based on a Weighted Average Cost of Transmission Projects
- Each Generic Generation Project Included its Pro-Rata Share of Transmission Cost

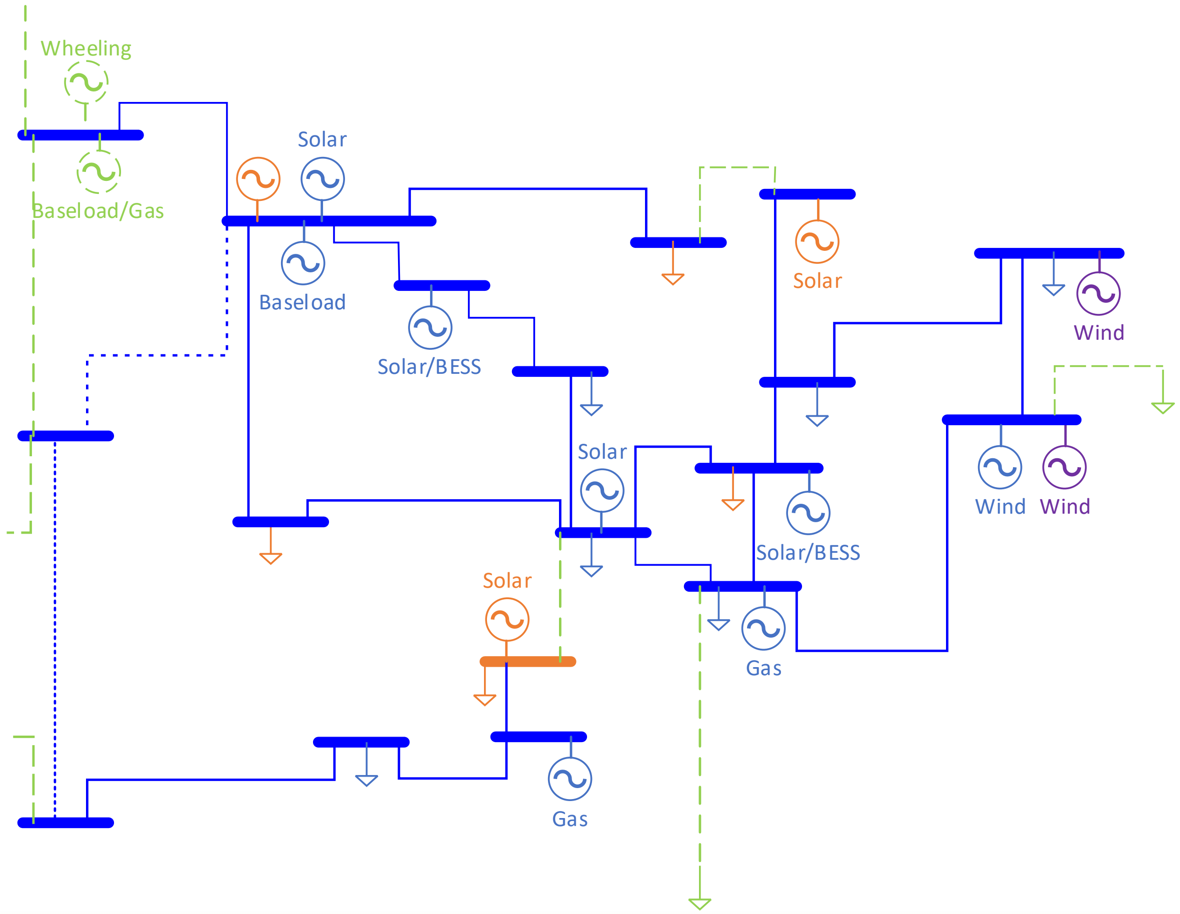
Pros: More Efficient, Informs About Transmission Expansion Needs Through Time

Cons: Less Accurate in the Near Term, Allows for a Smoother Buildout of Generation, Does not Inform About Optimal Location for Generation

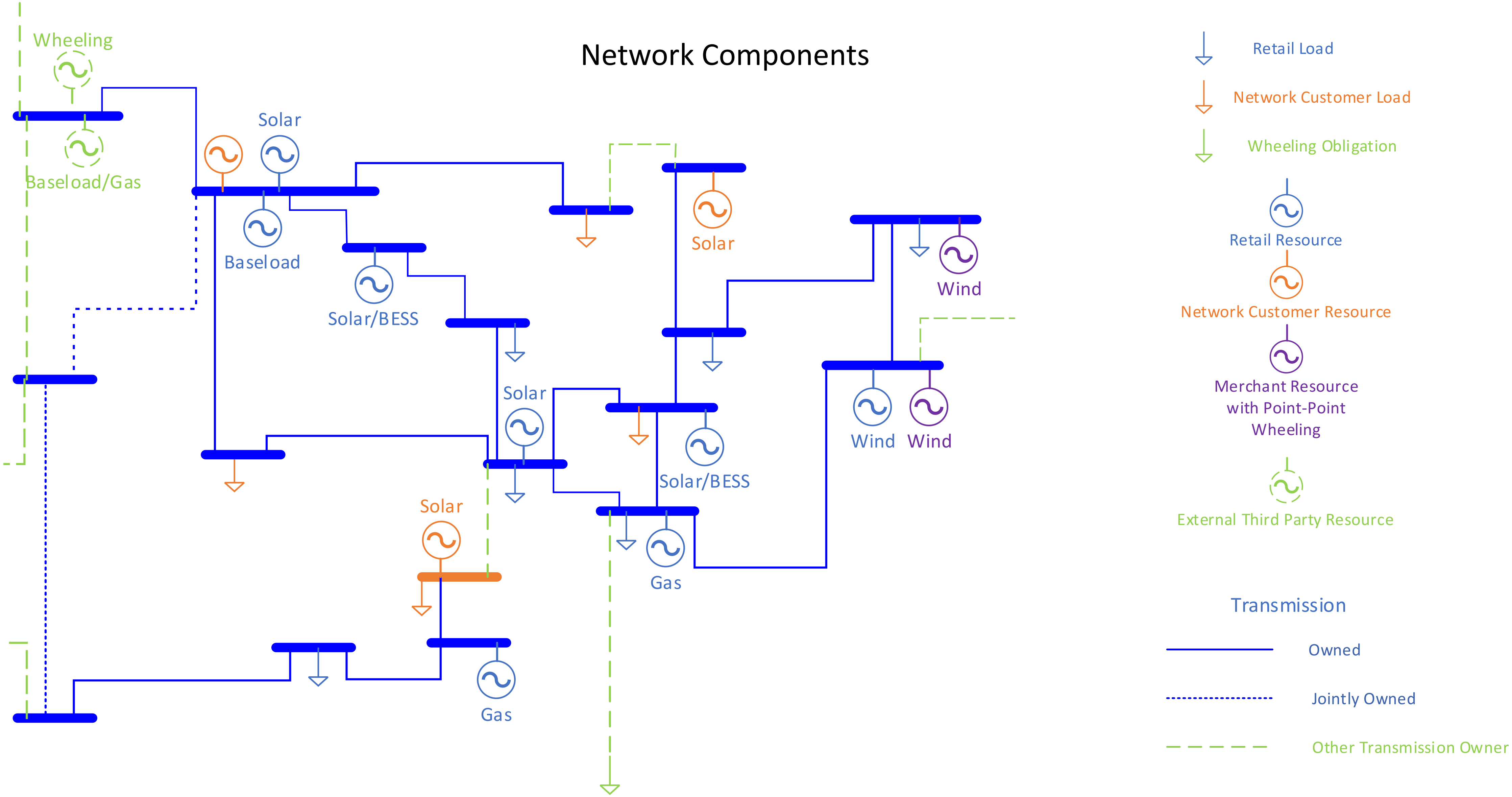
NODAL TRANSMISSION MODELING OVERVIEW

Nodal

- Detailed transmission system representation (DC power-flow) within a given zone
- Accounts for Balancing Area ("BA") interaction and wholesale customers
- LMP's for system nodes help determine system congestion
- Transmission outage optimization
- Short-term study periods (1-365) days

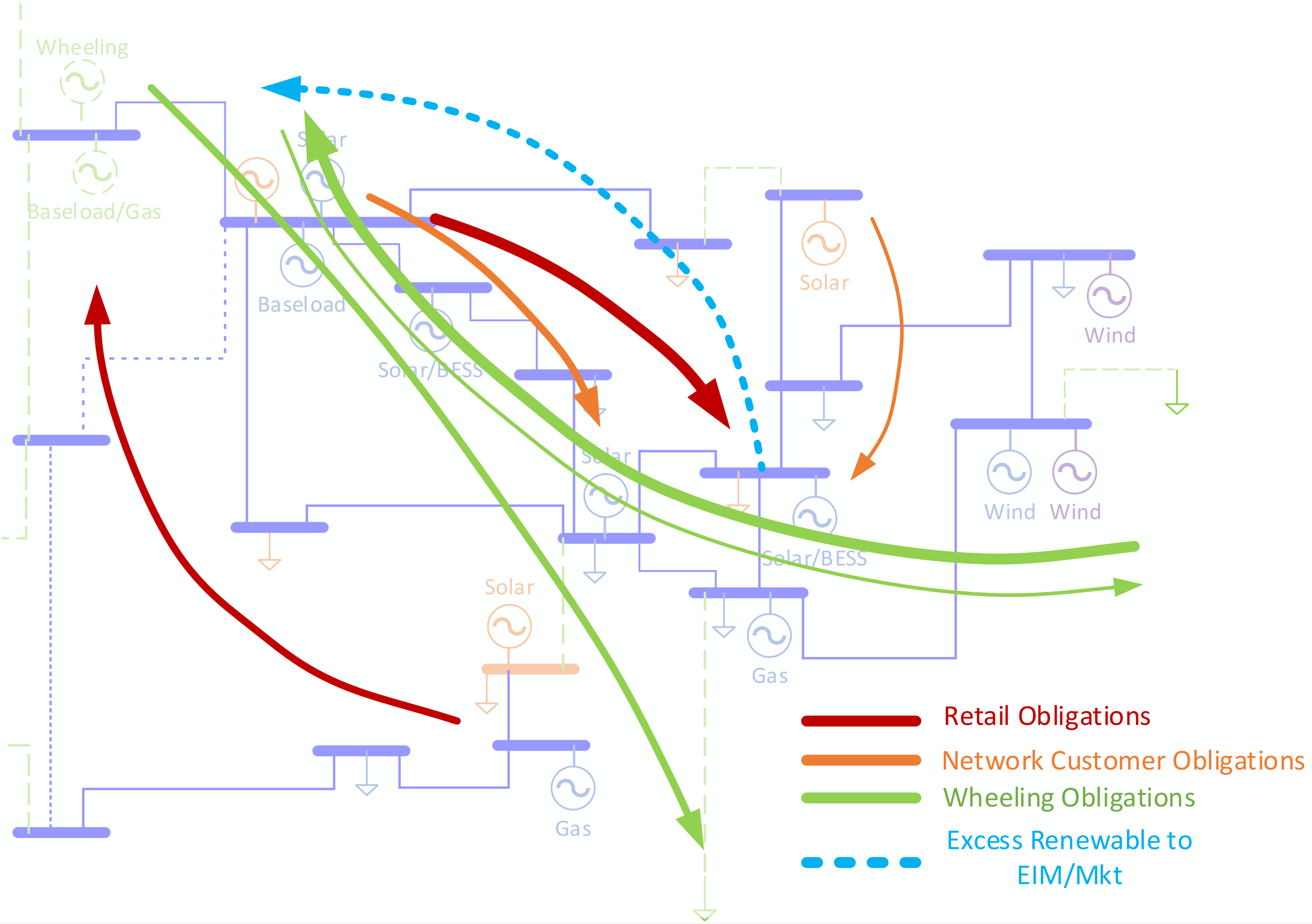


Network Components



Transmission Obligations

- Transmission flows depend on meeting all obligations.
- Timing of obligations are largely independent – especially wheeling.
- Obligations for renewables are largely unpredictable.
- Transmission must stay within limits regardless of obligations.
- Capacity available for a single user is not easily defined.



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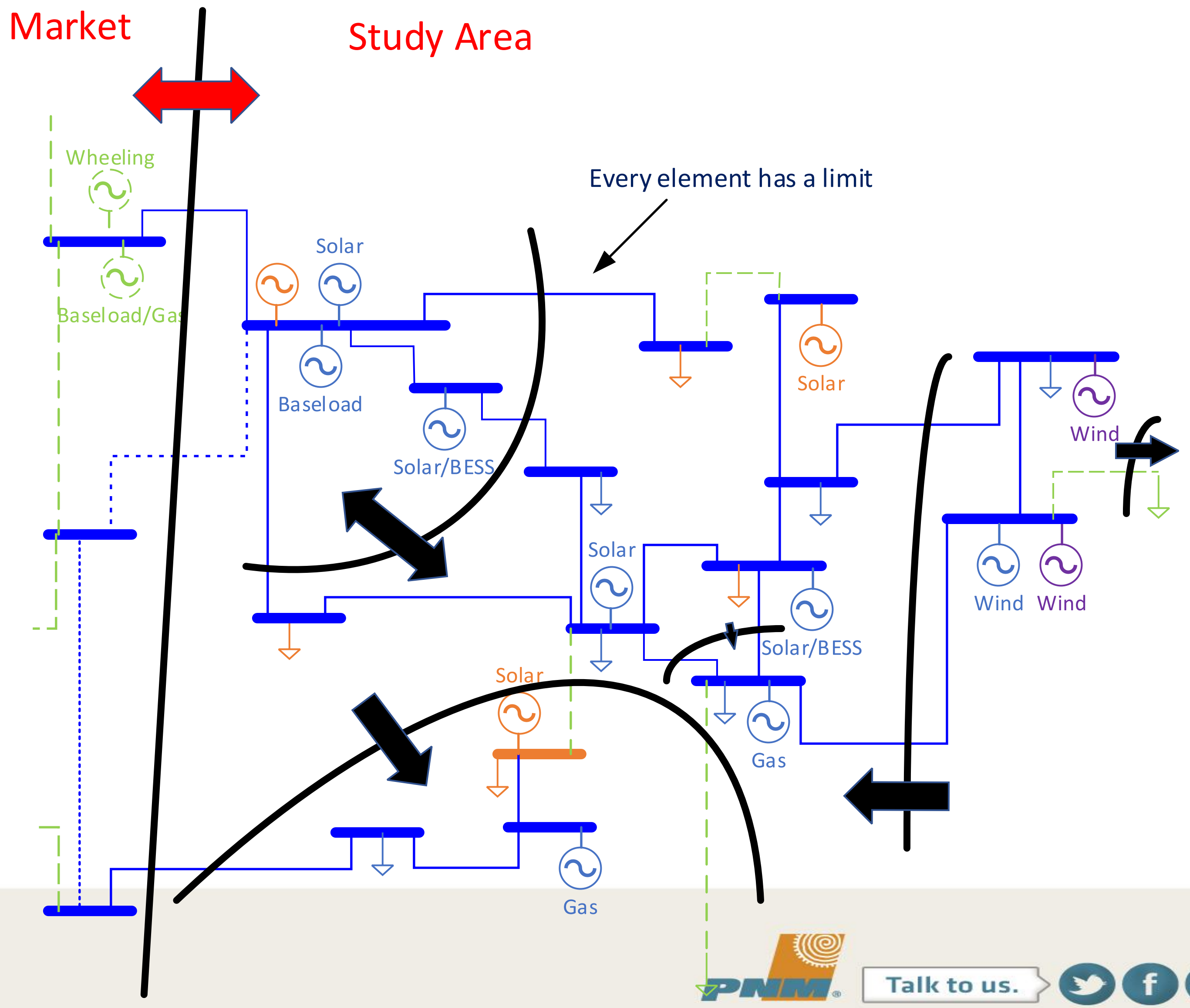
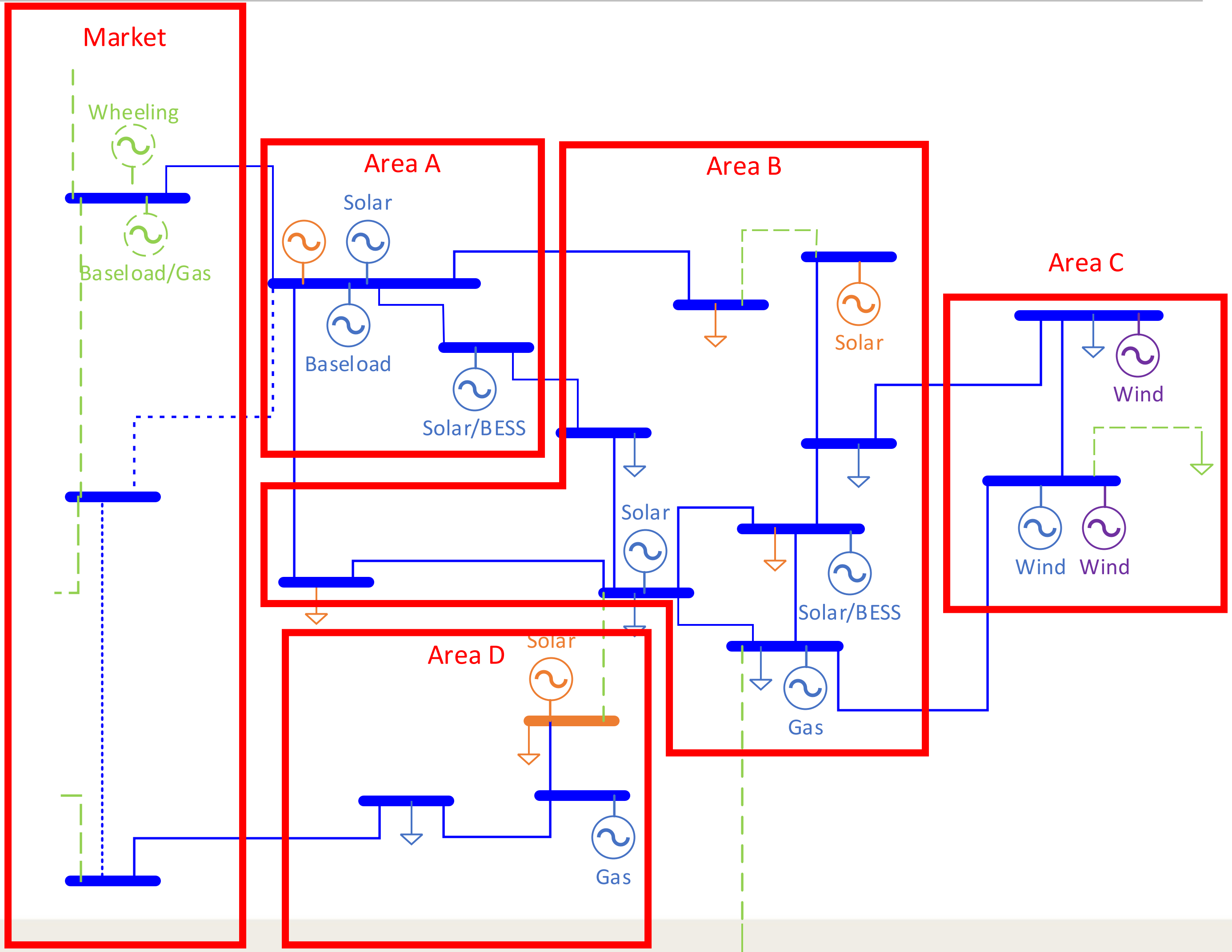
Transmission Limitations

- Every element has a limitation.
- Interface: limitations defined for a set of branches.
- May be possible to reach limit on some elements or interfaces in either direction.
- Interchange and limits with areas outside study area have a substantial impact on results.

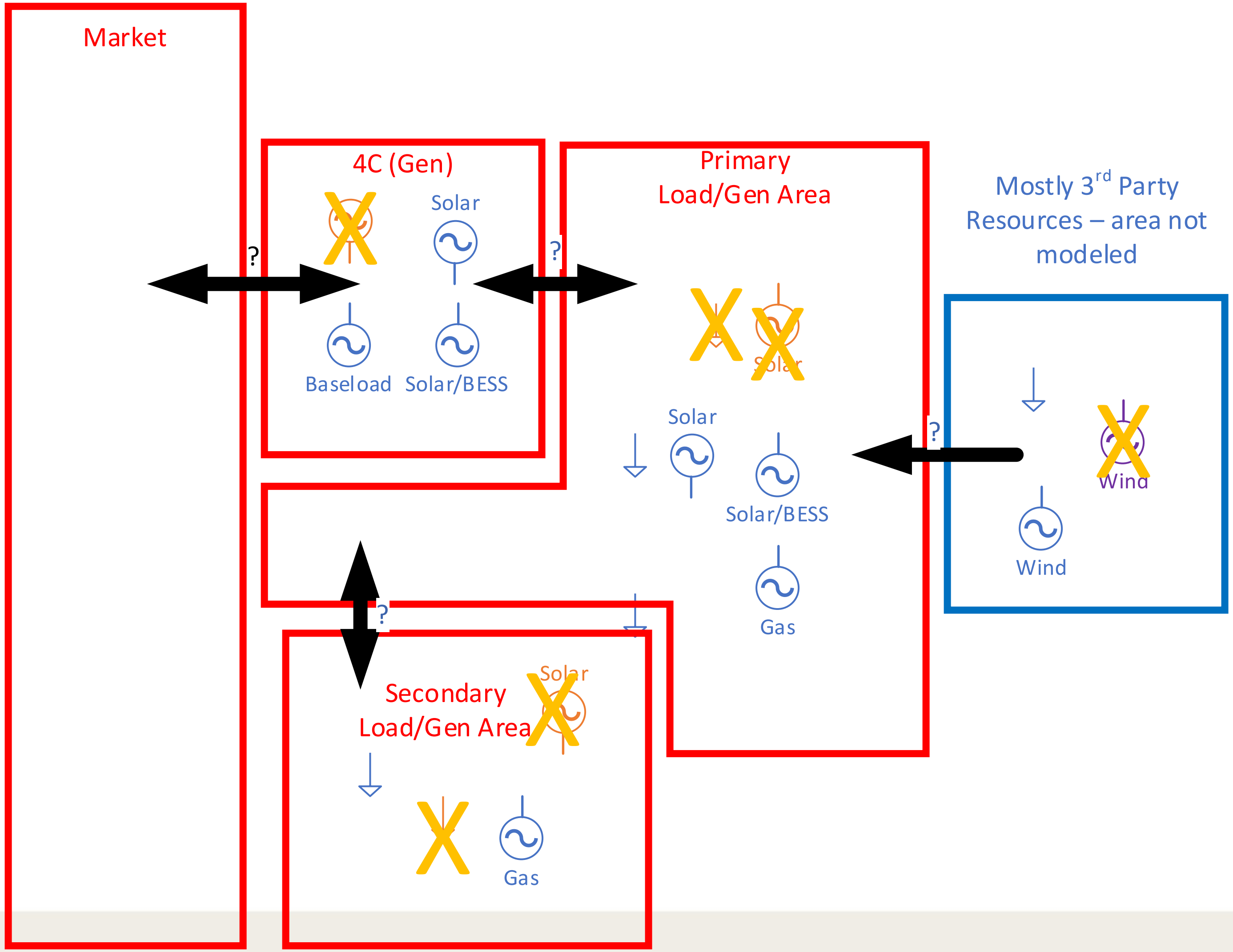


Zonal Areas

- Zonal models require specific geographic areas be defined that include a defined portion of the transmission system.
- Areas are typically based on BA boundaries and known element or interface limitations.
- Limitations between areas are estimated and may not adequately represent physics of system.



ZONAL MODEL LIMITATIONS



- PNM Load and Resources only modeled historically.
- Requires guessing at amount of transfer capability available for PNM retail.
- Transfers are not representative of actual transmission flows when other obligations are included resulting in potential to overstate or understate congestion.
- Local constraints not captured.
- May help with identifying better information for zonal model topology and transfer limits.

NODAL MODELING

Overlays the transmission grid (in more detail than pipe and bubble) against the generation dispatch

Detailed transmission line capability and specific elements of the system assessed on their value to the production cost

Allows non-retail utilization to be modeled

Captures the interaction between non-retail customers and PNM retail customers

NODAL MODELING CONSIDERATIONS

Better forecasting of actual transmission utilization and congestion associated with proposed IRP scenarios.

Help optimize storage amounts and locations around unused transmission capacity.

Nodal modeling can capture a greater subset of the transmission customers beyond retail.

Potentially over-optimizes transmission utilization and won't necessarily capture all customer behavior like redirecting transmission rights.

20-year runs will still require a zonal representation due to run-time requirements of nodal modeling.

NODAL TRANSMISSION MODELING

Expanding Encompass model to include a nodal model powerflow overlay

Building other customer data for model for integrate with PNM's production cost database

Model validation required thereafter against expected and neighboring entity interaction(s)

Expected to have preliminary models validated by Q1 2023

Continue to perfect database following runs and results assessments

Guides $Bs in generation and transmission investment, so it must be right!

NODAL TRANSMISSION MODELING: NEXT STEPS FOR IRP

Continue to perfect database following nodal transmission model runs and results assessments

→ **IRP**

Informs IRP modeling by providing robust framework in which to validate capacity expansion and production cost simulation results

↓

Transmission planning

Use in transmission planning by helping quantify congestion associated with interconnections and transmission service.

How can resource planning use nodal transmission model results to better inform IRP?

PNM IRP and Transmission teams to further investigate:

- Determine if insights from nodal modeling can help improved zonal representation for full IRP runs.
- Reduced system nodal model – physical power flow representation to improve runtimes
- Other avenues for using nodal transmission model to inform IRP – all options involve testing results against validated nodal transmission model
- Apply to development of considerations in a long-range transmission plan.

NEAR TERM SCHEDULE

FUTURE MEETING TIME & LOCATION

When: October 17, 2022

Topic: Public Advisory Steering Meeting #7: Emerging Grid Solutions

Start Time: 9:00 AM

Location: Virtual

NEXT MEETING

We encourage you to send in your thoughts ahead of time to IRP@pnm.com so that we can summarize them and distribute them for the next meeting. Please have your submissions in by October 12, 2022.

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