TRANSITIONING TO A CARBON-FREE GRID

PNM INTEGRATED RESOURCE PLANNING PRESENTATION FOR ALBUQUERQUE QUALITY NETWORK **AUGUST 17, 2023**

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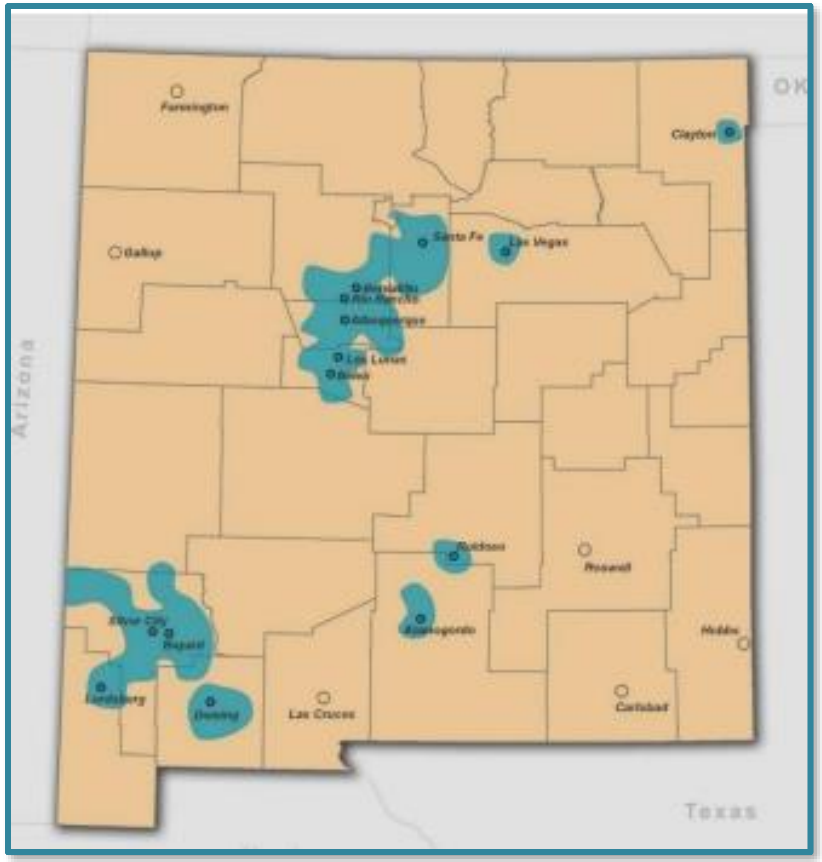
MEETING AGENDA

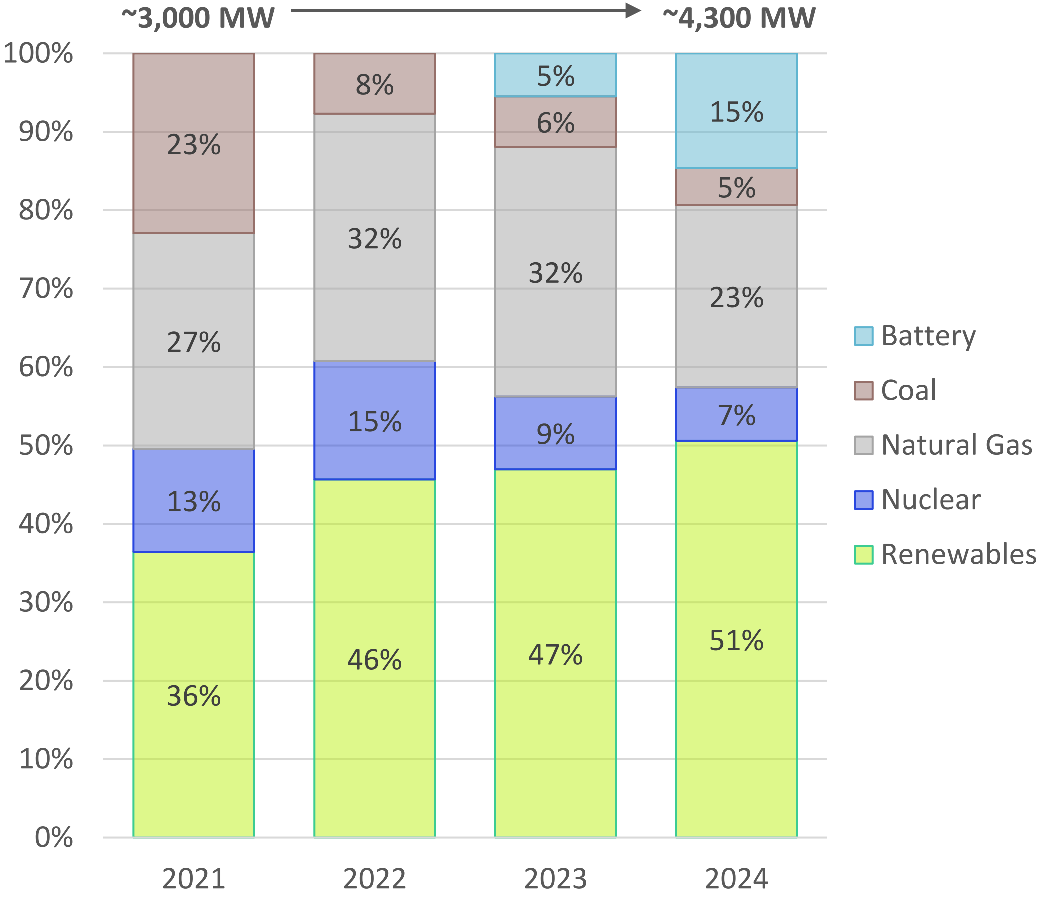
- Quick overview of PNM
- NM Energy Transition Act
- Planning and other challenges presented by an evolving system
- Transitioning to a carbon-free grid
- 2023 Integrated Resource Plan Framework and analysis

PNM OVERVIEW

PNM service territory:



PNM generation and storage capacity, % of total:

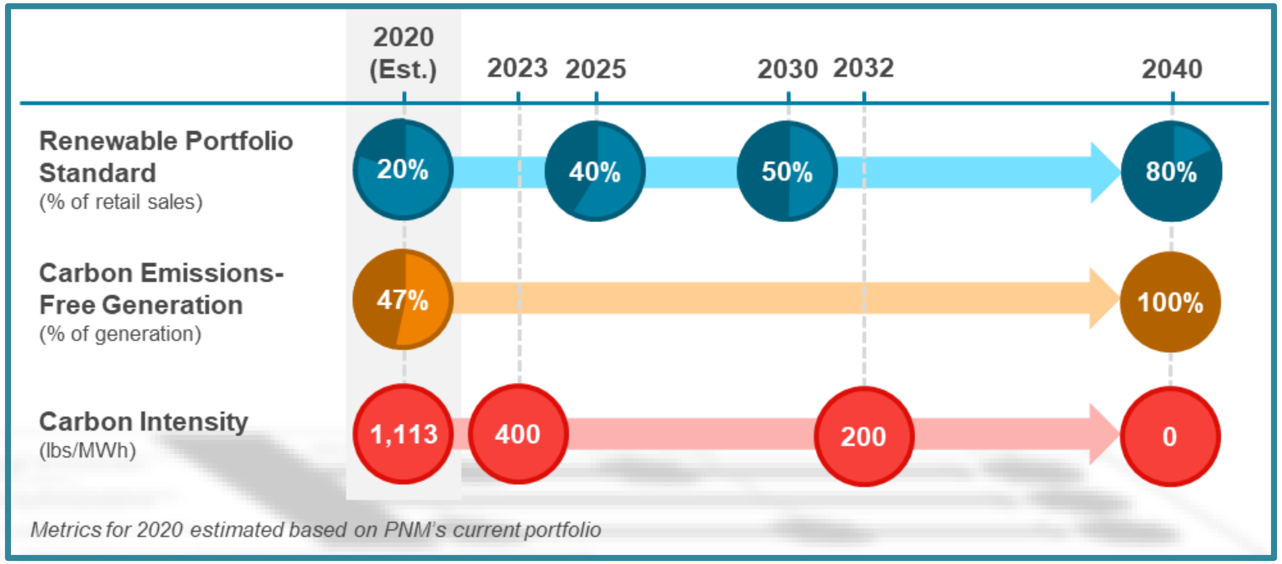


- ~1,200 New Mexico employees
- Serving 525,000 customers (40 communities)
- 15,000 miles of transmission and distribution line
- ~4,300 MW generation and storage capacity by year-end 2024
- Roughly 55% of load is currently served by carbon-free sources; we expect this to approach 70% by the end of 2024

NEW MEXICO ENERGY TRANSITION ACT

In 2019, the governor signed into law the Energy Transition Act (ETA), which established significant long-term targets for utilities within the state:

- By 2040, all retail sales must be supplied by 80% renewable generation; and
- By 2045, all retail sales must be supplied by 100% carbon emissions-free generation



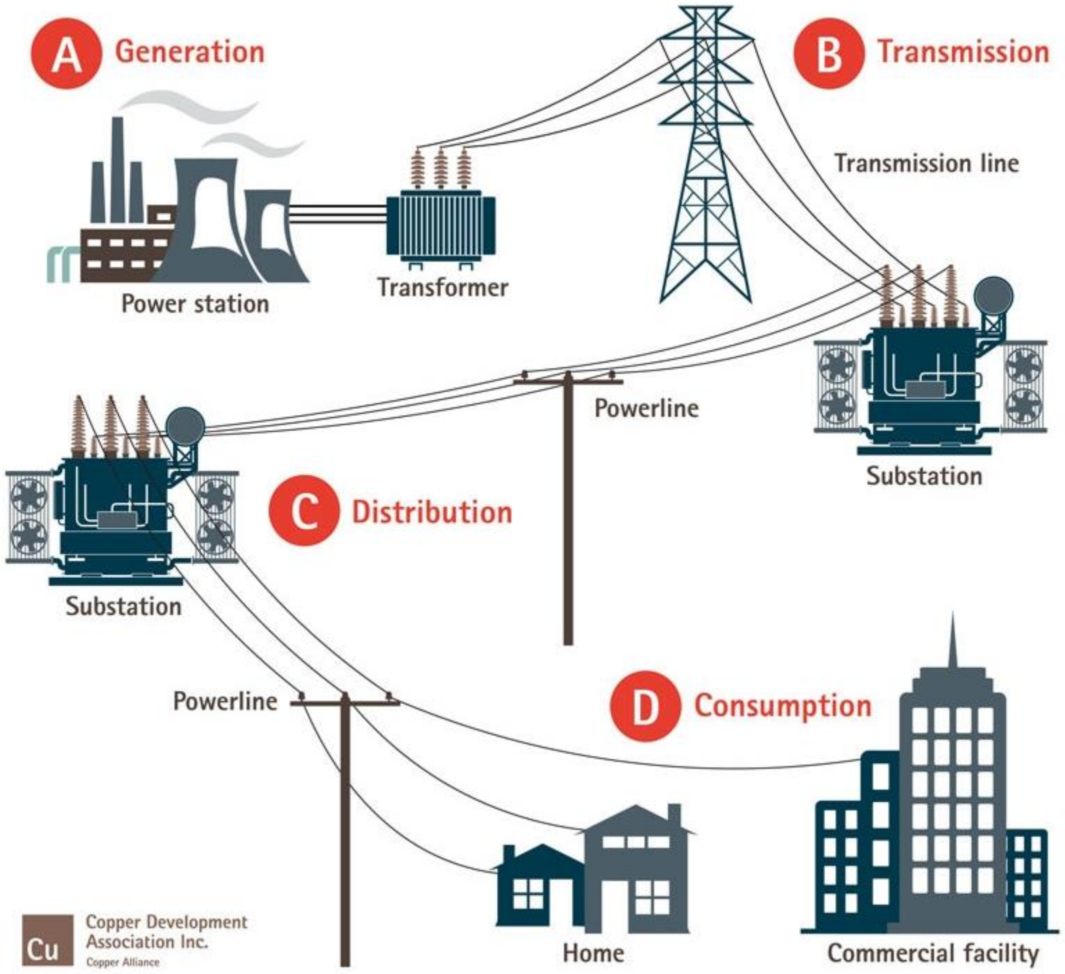
PLANNING AND OTHER CHALLENGES PRESENTED BY DECARBONIZATION

- The industry is rapidly changing, creating a challenging and uncertain environment for resource planning
- The ETA necessitates a rapid transformation of our grid – all components of a complex system must be redesigned from the ground up over the next ~15 years
- Planning objectives center around ensuring a reliable system while minimizing cost and meeting environmental and other regulatory and policy requirements
- In addition, significant uncertainties also pose risks:
    - Changing customer needs & preferences
    - Changing wholesale market dynamics
    - Changing technology options
- A transformed grid looks and operates very differently than the grid we have today

Planning objectives

Maintaining reliability	Planning Reserve Margin
	Loss of Load Expectation
	Operating Reserves
Minimizing cost	Net Present Value of Revenue Requirement
Mitigating environmental impact	Carbon Emissions
	Other Emissions
	Water Use
Meeting other regulatory requirements	EE Standards
	RPS Targets

THE TRADITIONAL SYSTEM



- Power generated at large central stations and delivered to customers through transmission and distribution system
- PNM has full control and visibility of system
- PNM balances system by matching generation to load
- Traditional generators are fully dispatchable and provide grid services along with energy

TOMORROW'S GRID: A GRID OF GRIDS

An Interconnected Power System Balancing Forecasted Resources with Dispatchable Loads

Source: "The Future of the Electric Grid and the Role of Energy Storage" Electric Power Research Institute, May 24, 2016

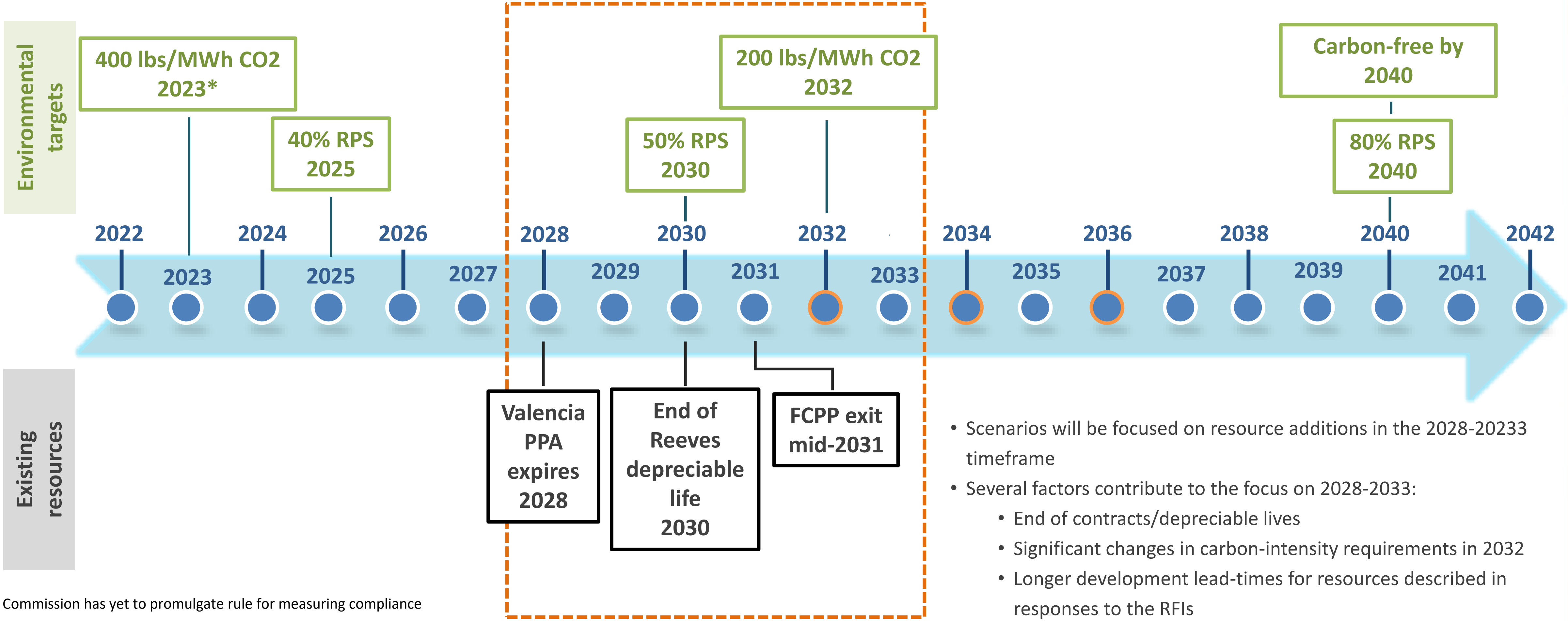
EXPECTATIONS FOR A CARBON-FREE GRID

PNM expects a carbon-free grid to be:

1. Sustainable
2. Reliable
3. Resilient
4. Affordable

2023 INTEGRATED RESOURCE PLAN FRAMEWORK

KEY ELEMENTS WITHIN TIMELINE FOR 2023 IRP ANALYSIS POINT TO 2028-2033 AS A CRITICAL PERIOD



- Scenarios will be focused on resource additions in the 2028-20233 timeframe
- Several factors contribute to the focus on 2028-2033:
  - End of contracts/depreciable lives
  - Significant changes in carbon-intensity requirements in 2032
  - Longer development lead-times for resources described in responses to the RFIs

* Commission has yet to promulgate rule for measuring compliance

THERE ARE MANY POTENTIAL PATHS TO CARBON-FREE

Base technologies only

PNM relies on solar, wind, and storage (lithium-ion) to meet future need and carbon emission reduction goals

Base + long-duration Storage

PNM makes a commitment to add long-duration storage in the 2028-2033 timeframe to meet future capacity need and facilitate clean energy transition

Base + natural gas

PNM allows new build of natural gas resources that will be converted to utilize hydrogen in 2040

Base + wind expansion

PNM seeks strategic transmission expansion in the late 2020's/early 2030s to integrate a large quantity of wind resources

Base + carbon capture

PNM relies on carbon capture and sequestration technologies to meet future capacity need and facilitate clean energy transition

Base + H2/early gas conversion

PNM pilots use of hydrogen before 2040 by creating green hydrogen via electrolysis for use in new or existing CTs

Energy efficiency and demand response included in all scenarios

2023 IRP MODELING CONSISTS OF THREE PHASES

Phase 1: simple scenarios

- Technologies modeled in isolation under Current Trends & Policy assumptions
- Allows understanding of how each technology changes outcomes relative to base technologies only

Phase 2: complex scenarios

- Technologies modeled in specified combinations under Current Trends & Policy assumptions
- Allows understanding of synergies between specific technologies

Phase 1-2 portfolios scored to inform groupings for Phase 3

Phase 3: optimized scenarios

- EnCompass model optimizes among a group of selected technologies in each scenario (“kitchen sink” scenarios)
- Scenarios modeled under Current Trends & Policy, High Economic Growth, Low Economic Growth, and National Carbon Policy assumptions
- Allows understanding of how optimal portfolio changes under different futures

PHASES 1 & 2 PORTFOLIO EVALUATION FOCUSES ON COST, RISK, AND CARBON EMISSIONS

RELIABILITY (INITIAL HURDLE)

- Check to ensure unserved energy is within a reasonable range
- Compare EnCompass portfolio EUE from extreme weather simulations to EUE from a SERVM tested reliable portfolio
- If EnCompass portfolio EUE falls within range of EUE from SERVM reliable portfolio, then portfolio/technology passes reliability test

COST (SCORE COMPONENT)

- Measured as present Value of Revenue Requirement, which reflects total cost of portfolio across study period
- Comparison of overall costs

TECHNOLOGY RISK (SCORE COMPONENT)

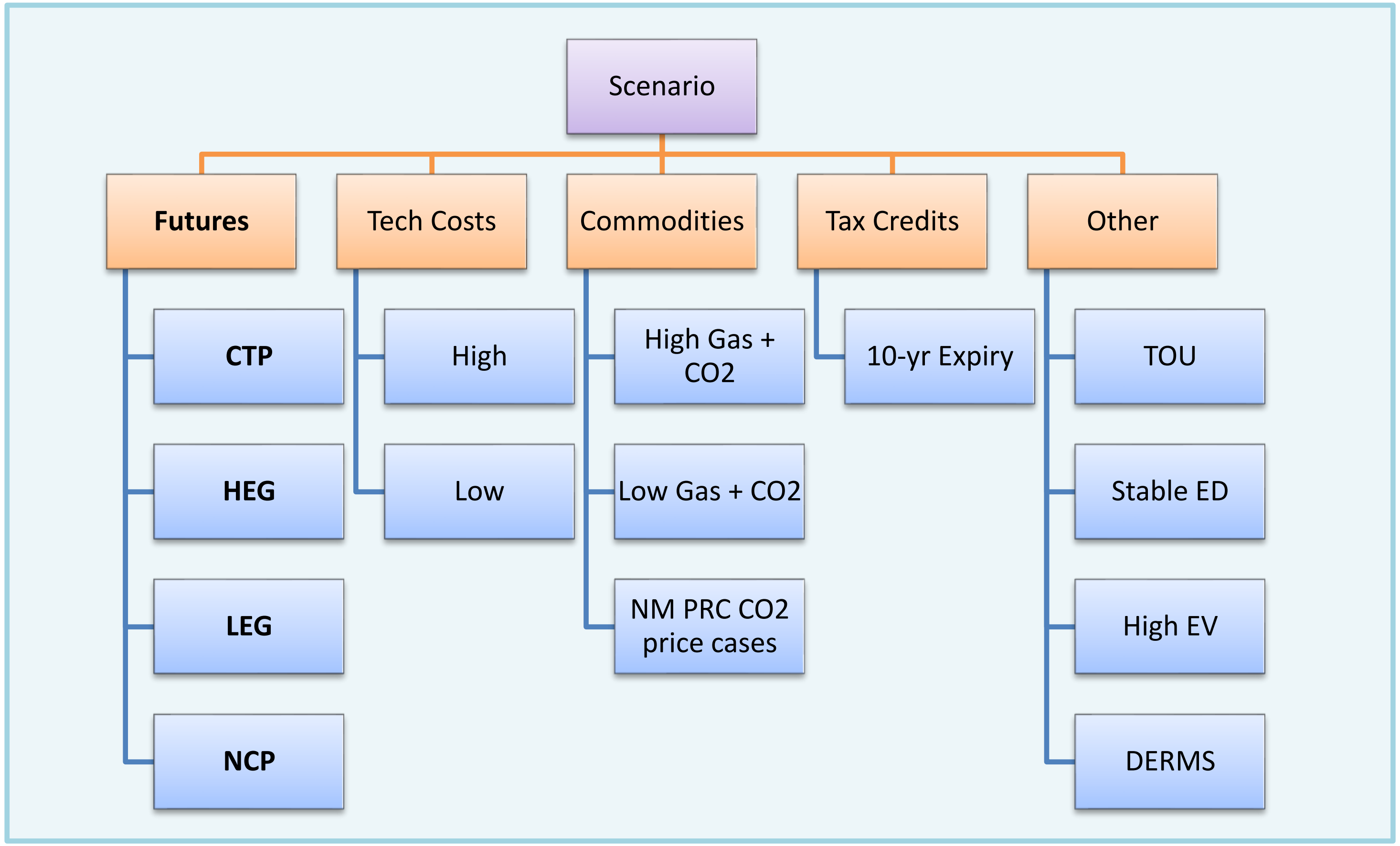
- Measured as a weighted average Technology Readiness Level
- Each portfolio assigned a weighted average TRL based on the 2032 firm capacity breakdown
- Comparison of dependence on less proven technologies on a firm capacity basis

CARBON EMISSIONS (SCORE COMPONENT)

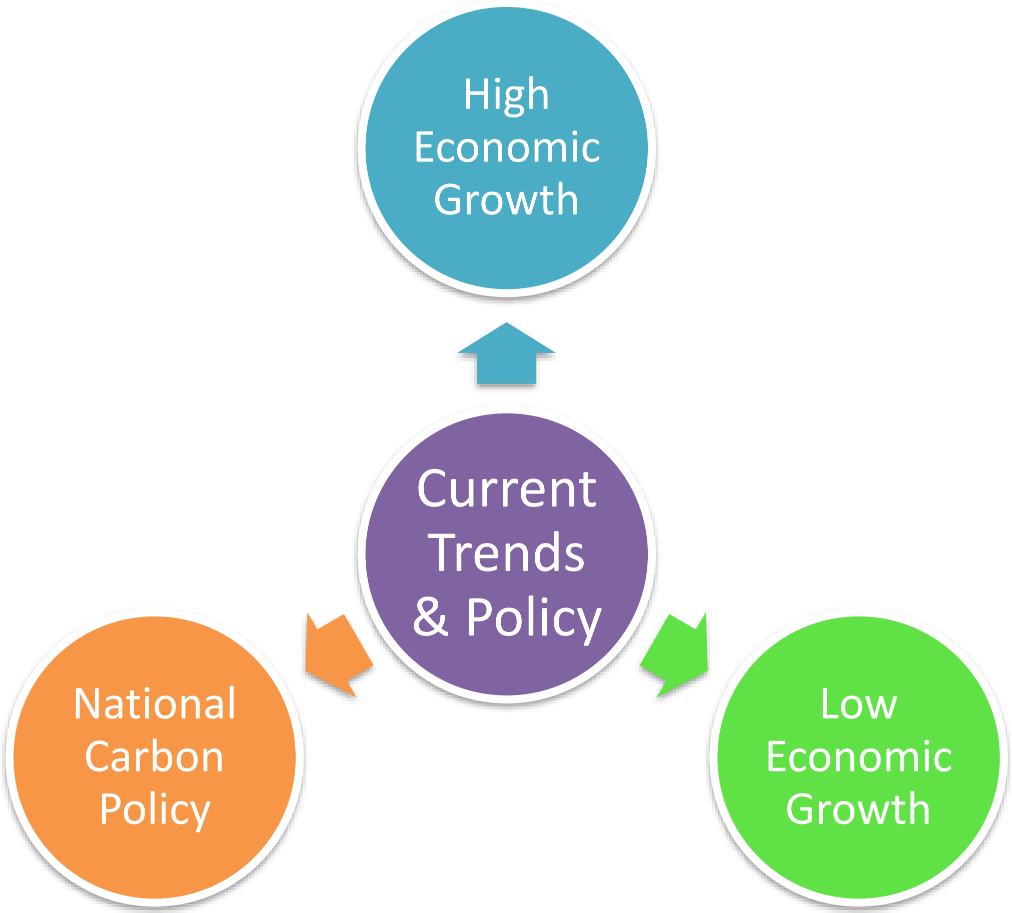
- Measured as NPV of total carbon emissions across study period (10% discount factor)
- Comparison of carbon emissions associated with scenario-specific combination of technologies
- Earlier abatement improves CO2 metric

- Each portfolio is given a score for each metric
- Portfolios in Phase 1-2 scored relative to all Phase 1-2 portfolios
- Unique technologies included in portfolios that have scores below the cutoff selected for Phase 3

PHASE 3 MODELING INCORPORATES A RANGE OF SENSITIVITY CASES



MANY FACTORS WILL CONTRIBUTE TO DETERMINATION OF MOST COST-EFFECTIVE PORTFOLIO(S)



Changes to evaluate across futures and sensitivities:

- What is the makeup of the portfolio under a given future/sensitivity?
- How does the portfolio change (i.e., which resources are included under different cases)?
- What are the associated reliability metrics?
- How do reliability metrics change across futures/sensitivities?
- What are the common characteristics/qualities that help system in each case?

RESOURCE ADEQUACY AND RESILIENCY MODELING ARE A CRITICAL COMPONENT OF IRP ANALYSIS

Resource Adequacy	Supply Resilience
Issues that can be captured in LOLP modeling	**Issues that require a deterministic case study framework**
Potential load/renewable events based on historical conditions	Extreme load/renewable events; specific ***worse case scenarios***
Randomly simulated outages	***Correlated outages*** due to ***external or common mode events*** beyond electricity (e.g. gas fuel supply during a polar vortex, natural disasters, etc.)
The frequency, magnitude, and duration of expected loss of load events	The ***acceptability of and response to the loss of load events*** modeled

APPENDIX

PHASE 1 SCENARIOS EXPLORE ATTRIBUTES OF A VARIETY OF TECHNOLOGIES

Scenario Name	Scenario-Specific Assumptions
Base technologies	Only solar, storage, and EE, DR allowed through 2032
LD storage - CAES	At least 100 MW of compressed air energy storage by 2032
LD storage - Flow	At least 100 MW of flow batteries by 2032
LD storage - IAS	At least 100 MW of iron air energy storage by 2032
LD storage - LAES	At least 100 MW of liquid air energy storage by 2032
LD storage - PHS 8-hr	300 MW of pumped storage (8hr) by 2032
LD storage - PHS 70-hr	300 MW of pumped storage (70hr) by 2032
LD storage - Thermal	At least 150 MW of thermal energy storage by 2032
Thermal - CT	New hydrogen-ready CTs allowed
Thermal - Linear	New hydrogen-ready linear generators allowed
Wind expansion	New wind & associated transmission allowed beginning in 2028
CCS - CCGT retrofit	Afton CC (235 MW) retrofitted with CCS capability
CCS - Net Power	280 MW NET power plant added by 2032
Green hydrogen	~250 MW hydrogen-fueled CT & ~750 MW electrolyzer added in 2031

- In Phase 1, technology-specific scenarios are screened under the following conditions:
  1. **CT&P future (capacity expansion run)**
     a) P50 load 8760 production cost run
     b) Extreme weather load 8760 production cost run
- **This approach gives PNM the ability to evaluate scenarios based on:**
  - Overall cost
  - Ability to accommodate extreme weather load
- All portfolios include option to add base technologies (including DR and EE) at any time
- ***All portfolios required to meet reliability, RPS, and carbon-intensity targets***

PHASE 2 SCENARIOS EXPLORE SYNERGIES BETWEEN TECHNOLOGIES

Preliminary

Scenario Name	Scenario-Specific Assumptions
PHS 70-hr + CT	300 MW of pumped storage (70-hr) by 2032; new hydrogen-ready CTs allowed
PHS 70-hr + CT + wind	300 MW of pumped storage (70-hr) by 2032; new hydrogen-ready CTs allowed; new wind beginning in 2028
PHS 70-hr + Linear gen.	300 MW of pumped storage (70-hr) by 2032; new hydrogen-ready linear generators allowed
PHS 70-hr + Afton CCS	300 MW of pumped storage (70-hr) by 2032; Afton CC (235 MW) retrofitted with CCS capability
PHS 8-hr + CT	300 MW of pumped storage (8-hr) by 2032; new hydrogen-ready CTs allowed
PHS 8-hr + CT + wind	300 MW of pumped storage (8-hr) by 2032; new hydrogen-ready CTs allowed; new wind beginning in 2028
PHS 8-hr + Linear gen.	300 MW of pumped storage (8-hr) by 2032; new hydrogen-ready linear generators allowed
PHS 8-hr + Afton CCS	300 MW of pumped storage (8-hr) by 2032; Afton CC (235 MW) retrofitted with CCS capability
IAS + CT	At least 100 MW of iron air energy storage by 2032; new hydrogen-ready CTs allowed
IAS + CT + wind	At least 100 MW of iron air energy storage by 2032; new hydrogen-ready CTs allowed; new wind beginning in 2028
IAS + Linear gen.	At least 100 MW of iron air energy storage by 2032; new hydrogen-ready linear generators allowed
IAS + Afton CCS	At least 100 MW of iron air energy storage by 2032; Afton CC (235 MW) retrofitted with CCS capability
Wind expansion + CAES	At least 100 MW of compressed air energy storage by 2032; new wind beginning in 2028
Wind expansion + BESS	New wind beginning in 2028; battery storage can be added in wind zone
IAS + LAES	At least 100 MW of iron air energy storage and at least 100 MW liquid air energy storage by 2032
Green hydrogen + wind	~250 MW hydrogen-fueled CT & ~750 MW electrolyzer added in 2031; new wind beginning in 2028
Flow + CT	At least 100 MW of flow batteries (10-hr) by 2032; new hydrogen-ready CTs allowed
Flow + CCS	At least 100 MW of flow batteries (10-hr) by 2032; Afton CC (235 MW) retrofitted with CCS capability
Base tech + CT + LDES	Model has option to add base technologies, CTs (2026+), and any long-duration storage technology (2028-2033)
Base tech + LDES	Model has option to add base technologies and any long-duration storage technology (2028-2033)

- In Phase 2, PNM designed more complex portfolios consisting of two or more RFI technologies – the intent is to explore synergistic effects of combining operating characteristics
- All portfolios include option to add base technologies (including DR and EE) at any time
- Scenarios are screened under the same conditions as in Phase 1
- ***All portfolios required to meet reliability, RPS, and carbon-intensity targets***

2023 IRP CORE FUTURES

Key assumption	Current Trends & Policy	High Economic Growth	Low Economic Growth	National Carbon Policy (Carbon-free by 2035)
Load forecast	Mid	**High**	**Low**	**High**
BTM PV forecast	Mid	**High**	**Low**	**High**
EV adoption forecast	Mid	**High**	**Low**	**High**
Building Electrification Forecast	Mid	Mid	Mid	**High**
Economic development	Limited	**Stable**	Limited	**Stable**
Gas price forecast	Mid	Mid	**Low**	**High**
Carbon price forecast	Mid	Mid	Mid	**High**
Technology cost forecast	Mid	Mid	Mid	**Low**

2023 IRP SENSITIVITIES

	Sensitivity	Load forecast	Economic Development	BTM PV forecast	EV adoption forecast	Building electrification	Gas price forecast	CO2 price forecast	Technology costs	IRA tax credits & incentives
Load	High load	**High**	Limited ED	Mid	Mid	Mid	Mid	Mid	Mid	Extended
	Strong ED growth	Mid	**Stable**	Mid	Mid	Mid	Mid	Mid	Mid	Extended
	Very strong ED growth	Mid	**Stable**	Mid	Mid	Mid	Mid	Mid	Mid	Extended
	Extreme weather	**P90 hot/cold**	Limited ED	Mid	Mid	Mid	Mid	Mid	Mid	Extended
	Low load	**Low**	Limited ED	Mid	Mid	Mid	Mid	Mid	Mid	Extended
	TOU pricing	**TOU shaping**	Limited ED	Mid	Mid	Mid	Mid	Mid	Mid	Extended
BTM	High BTM PV	Mid	Limited ED	**High**	Mid	Mid	Mid	Mid	Mid	Extended
	Low BTM PV	Mid	Limited ED	**Low**	Mid	Mid	Mid	Mid	Mid	Extended
	No BTM PV	Mid	Limited ED	**Zero**	Mid	Mid	Mid	Mid	Mid	Extended
	High EV adoption	Mid	Limited ED	Mid	**High**	Mid	Mid	Mid	Mid	Extended
	Low EV adoption	Mid	Limited ED	Mid	**Low**	Mid	Mid	Mid	Mid	Extended
	High building electrification	Mid	Limited ED	Mid	Mid	**High**	Mid	Mid	Mid	Extended
	DERMS	Mid	Limited ED	**High**	**High**	Mid	Mid	Mid	Mid	Extended
Gas price	High gas price	Mid	Limited ED	Mid	Mid	Mid	**High**	Mid	Mid	Extended
	Low gas price	Mid	Limited ED	Mid	Mid	Mid	**Low**	Mid	Mid	Extended
Carbon price	IRP rule $40 CO2 price	Mid	Limited ED	Mid	Mid	Mid	Mid	**$40/ton**	Mid	Extended
	IRP rule $20 CO2 price	Mid	Limited ED	Mid	Mid	Mid	Mid	**$20/ton**	Mid	Extended
	IRP rule $8 CO2 price	Mid	Limited ED	Mid	Mid	Mid	Mid	**$8/ton**	Mid	Extended
	PNM high CO2 price	Mid	Limited ED	Mid	Mid	Mid	Mid	**High**	Mid	Extended
	PNM mid CO2 price	Mid	Limited ED	Mid	Mid	Mid	Mid	Mid	Mid	Extended
	PNM low CO2 price	Mid	Limited ED	Mid	Mid	Mid	Mid	**Low**	Mid	Extended
Technology costs	Fast technology advancement	Mid	Limited ED	Mid	Mid	Mid	Mid	Mid	**Low**	Extended
	Slow technology advancement	Mid	Limited ED	Mid	Mid	Mid	Mid	Mid	**High**	Extended
	IRA tax credits expire	Mid	Limited ED	Mid	Mid	Mid	Mid	Mid	Mid	**Expire 2032-2034**

TECHNOLOGY READINESS LEVEL DEFINITIONS

TRL 0 – Idea phase

- Unproven Concept with no testing having been done

TRL 1 – Basic Research

- Needs of the technology can be described, but have no evidence

TRL 2 – Technology Formulation

- Concept and application have been formulated

TRL 3 – Needs Validation

- You have an initial "offering", stakeholders are interested

TRL 4 – Small Scale Prototype

- Built in laboratory environment.

TRL 5 – Large Scale Prototype

- Tested in intended environment

TRL 6 – Prototype System

- Tested in intended environment with close to expected performance

TRL 7 – Demonstration System

- Operating in operational environment at pre-commercial scale

TRL 8 – First of Kind Commercial System

- All technical processes and systems to support commercial activity at ready state

TRL 9 – Full Commercial Application

- Technology on "general availability" for all consumers

Thank you

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