2022 Integrated Resource Plan (IRP)

Public Advisory Meeting #3

6/27/2022

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Agenda and Introductions

Stewart Ramsay, Managing Executive, Vanry & Associates

Agenda

Time	Topic	Speakers
Morning **Starting at 10:00 AM**	Virtual Meeting Protocols and Safety, Schedule	Chad Rogers, Senior Manager, Regulatory Affairs, AES Indiana
	IRP Midway Touchpoint	Kristina Lund, President & CEO, AES Indiana
	Stakeholder Presentations	Wendy Bredhold, Senior Campaign Representative, Sierra Club Ray Wilson, Faith in Place
	IRP Schedule & Meeting #2 Recap	Erik Miller, Manager, Resource Planning, AES Indiana
	2022 All-Source RFP & Replacement Resource Cost Update	Erik Miller, Manager, Resource Planning, AES Indiana
	Commodity Forecasts	Erik Miller, Manager, Resource Planning, AES Indiana
	RTO Reliability Planning: Resource Adequacy & Seasonal Construct	Lynn Hecker, Senior Manager, Resource Adequacy Policy and Analytics, MISO
Break **12:00 PM – 12:30 PM**	Lunch	
Afternoon **Starting at 12:30 PM**	Modeling Reliability Assumptions	Erik Miller, Manager, Resource Planning, AES Indiana
	Reliability Analysis	Hisham Othman, VP Transmission and Regulatory Consulting, Quanta
	Portfolio Metrics & Scorecard	Erik Miller, Manager, Resource Planning, AES Indiana
	AES Indiana Distribution System Planning	Kathy Storm, Vice President, US Smart Grid, AES Indiana Mike Russ, Senior Manager, T&D Forecasting, AES Indiana
	Final Q&A and Next Steps	

Virtual Meeting Protocols and Safety

Chad Rogers, Senior Manager, Regulatory Affairs, AES Indiana

IRP Team Introductions

AES Indiana Leadership Team

Kristina Lund, President & CEO, AES Indiana

Aaron Cooper, Chief Commercial Officer, AES Indiana

Brandi Davis-Handy, Chief Public Relations Officer, AES Indiana

Ahmed Pasha, Chief Financial Officer, AES Indiana

Tom Raga, Vice President Government Affairs, AES Indiana

Sharon Schroder, Managing Director, Regulatory Affairs, AES Indiana

Kathy Storm, Vice President, US Smart Grid, AES Indiana

AES Indiana IRP Planning Team

Joe Bocanegra, Load Forecasting Analyst, AES Indiana

Erik Miller, Manager, Resource Planning, AES Indiana

Scott Perry, Manager, Regulatory Affairs, AES Indiana

Chad Rogers, Senior Manager, Regulatory Affairs, AES Indiana

Mike Russ, Senior Manager, T&D Planning & Forecasting, AES Asset Management

Brent Selvidge, Engineer, AES Indiana

Will Vance, Senior Analyst, AES Indiana

Kelly Young, Director, Public Relations, AES Indiana

AES Indiana IRP Partners

Annette Brocks, Senior Resource Planning Analyst, ACES

Patrick Burns, PV Modeling Lead and Regulatory/IRP Support, Brightline Group

Eric Fox, Director, Forecasting Solutions, Itron

Jeffrey Huber, Overall Project Manager and MPS Lead, GDS Associates

Jordan Janflone, EV Modeling Forecasting, GDS Associates

Patrick Maguire, Executive Director of Resource Planning, ACES

Hisham Othman, Vice President, Transmission and Regulatory Consulting, Quanta Technology

Stewart Ramsey, Managing Executive, Vanry & Associates

Mike Russo, Forecast Consultant, Itron

Jacob Thomas, Market Research and End-Use Analysis Lead, GDS Associates

Melissa Young, Demand Response Lead, GDS Associates

AES Indiana Legal Team

Nick Grimmer, Indiana Regulatory Counsel, AES Indiana

Teresa Morton Nyhart, Counsel, Barnes & Thornburg LLP

Welcome to Today's Participants

ACES
Advanced Energy Economy
All Souls Indianapolis
Barnes & Thornburg LLP
Boardwalk Pipelines
Butler University
Carmel Green Initiative
CCR
CenterPoint Energy
Citizens Action Coalition
City of Indianapolis
Clean Grid Alliance
Develop Indy | Indy Chamber
Duke Energy
E&C
Earth Charter Indiana
EDF Renewables NA
Energy Futures Group
Faith in Place
Fluence Energy
GDS Associates
Hallador Energy
Hoosier Energy

IBEW Local Union 1395
Indiana Chamber
Indiana DG
Indiana Distributed Energy Alliance
Indiana Energy Association
Indiana Utility Regulatory Commission
Indiana State Conference of the NAACP
IUPUI
NIPSCO
NuScale Power
Office of Utility Consumer Counselor
Power Takeoff
Purdue - State Utility Forecasting Group
Ranger Power
Reliable Energy
Rolls-Royce/ISS
Sierra Club
Solar United Neighbors
Synapse Energy Economics
Wartsila

… and members of the AES Indiana team and the public!

Virtual Meeting Best Practices

Questions

- → Your candid feedback and input is an integral part to the IRP process.
- → Questions or feedback will be taken at the end of each section.
- → Feel free to submit a question in the chat function at any time and we will ensure those questions are addressed.

Audio

- → All lines are muted upon entry.
- → For those using audio via Teams, you can unmute by selecting the microphone icon.
- → If you are dialed in from a phone, press *6 to unmute.

Video

- → Video is not required. To minimize bandwidth, please refrain from using video unless commenting during the meeting.

AES Purpose & Values

Accelerating the future of energy, **together**.

Safety first

Highest standards

All together

Our safety beliefs

1. Safety comes first for our people, our contractors and our communities.

2. All occupational incidents can be prevented.

3. Working safely is a condition of employment.

4. All AES people and contractors have the right and obligation to stop work when they identify a situation they believe to be unsafe

We can all be safety leaders.

IRP Midway Touchpoint

AES

- Fortune 200 company with operations in 14 countries across 4 continents.
- Track record of innovation in the technologies that are transforming the energy sector.
- AES is a global energy company and with the addition of 5 GW of new renewables in 2021, is now positioned as the fastest growing US renewables developer and the largest supplier of corporate renewables contracts in the world.
- AES announced a target to exit coal by year-end 2025 at the global portfolio level, subject to meeting regulatory obligations. The exit may be achieved through asset sales, fuel conversions or retirements.

AES Indiana

- 20-year IRP plan created with stakeholder input.
- Modeling and analysis culminates in a preferred resource portfolio and a short-term action plan.
- The need for a utility to engage in a rigorous stakeholder process and describe how the utility plans to deliver safe, reliable and efficient electricity at just and reasonable rates is a legal requirement in Indiana and is an obligation AES Indiana will meet.

Leading the inclusive, clean energy transition

1. AES Indiana has a diverse power generation portfolio that serves our customers' needs today and well into the future.

2. Our 2019 IRP projected that AES Indiana would achieve a reduction in carbon intensity of more than 40% from 2015 to 2025.

3. AES Indiana has been incorporating new technologies and fuels into its generation fleet for more than a decade.
    - Signed power purchase agreements with wind farms back beginning in 2009
    - Converted Harding Street from coal to natural gas
    - Retired Eagle Valley coal and started operations of a new CCGT in 2018
    - Announced plans to retire Petersburg Unit 1 in 2021 and Unit 2 in 2023 and signed the acquisitions of Hardy Hills (195 MW solar project) and the Petersburg Energy Center (250 MW solar and 180 MWh energy storage project)

4. AES Indiana is committed to safety and compliance of all environmental regulations and will responsibly close ash ponds in the manner required by Indiana state law.

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Stakeholder Presentations

Wendy Bredhold, Senior Campaign Representative, Sierra Club
Tony Mendoza, Senior Attorney, Sierra Club

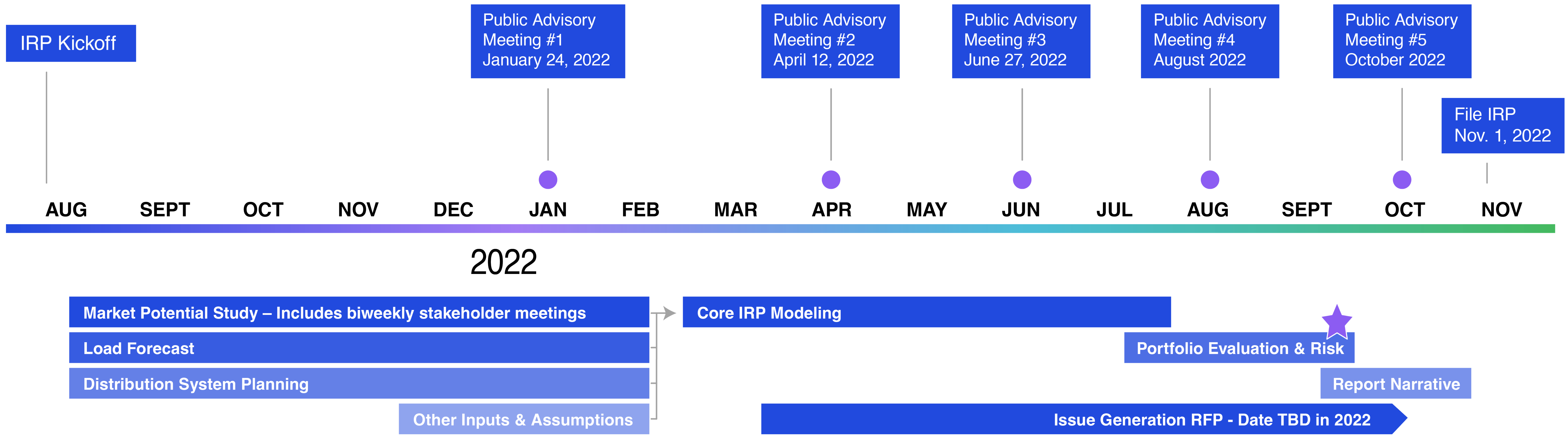
Stakeholder Presentations

Ray Wilson, Faith in Place

IRP Schedule & Meeting #2 Recap

Erik Miller, Manager, Resource Planning, AES Indiana

Updated 2022 IRP Timeline



● = Stakeholder Technical Meeting for stakeholders with executed NDAs held the week before each public stakeholder meeting

★ = Preferred Resource Portfolio selected

AES Indiana is available for additional touchpoints with stakeholders to discuss IRP-related topics.

AES Indiana

Public Advisory Schedule

Public Advisory Meeting #1 – January 24, 2022

- 2022 IRP Schedule & Progress
- 2019 IRP Recap
- Load, EV, DG Forecasts
- MPS Overview

Public Advisory Meeting #2 – April 12, 2022

- Load Scenarios
- MPS Results & DSM Inputs
- Replacement Resource Assumptions
- IRP Portfolio Matrix & Scenario Framework

Public Advisory Meeting #3- June 27, 2022

- Stakeholder Presentations
- Portfolio Metrics & Scorecard Framework
- MISO Reliability Planning
- IRP Reliability Analysis
- Distribution System Plan

Public Advisory Meeting #4 - August

- Preliminary Modeling Results
- Risk Analysis
- Preliminary Scorecard Results

Public Advisory Meeting #5 - October

- 2022 Modeling Insights
- Preferred Resource Portfolio & Short-Term Action Plan

Topics for meetings 4-5 are subject to change depending on modeling progress.

IRP Process Overview

DSM Market Potential Study (MPS)
- → End Use Analysis
- → Comprehensive measure list
- → Measure uptake & potentials: MAP & RAP
- → Develop IRP model inputs (bundles)

Replacement Resource Costs
- → Cost assumptions from 2020 RFP and Consultants, e.g. Wood Mackenzie, NREL
- → New RFP issued date TBD in 2022

Distribution System Planning (DSP)
- → Bottom-up forecast on sample of constrained circuits
- → Assess EV and DG impacts
- → Load shapes inform IRP analysis

Load Forecast
- → Itron SAE Methodology
- → Base, High & Low Scenarios
- → IRP model peak and energy inputs

Core IRP Modeling & Evaluation

Capacity Expansion Modeling
- → Retirement and replacement analysis
- → Portfolio optimization

Production Cost Modeling & PVRR
- → Prod Cost - Portfolio dispatch analysis serve as PVRR inputs
- → Portfolio PVRR analysis
- → Stochastic risk analysis

Portfolio Evaluation & Short-Term Action Plan
- → Screen against Evaluation Criteria
- → Selection of Preferred Resource Portfolio & Short-Term Action Plan

Other Inputs & Assumptions
- → Portfolio and scenario framework
- → Power & Commodity Price Forecasts
- → Model Parameters & Constraints
- → Existing Resources

IRP Submitted Nov. 1, 2022

IRP-driven Filings
- → DSM Filing
- → Certificate of Public Convenience and Necessity (CPCN) Filing

Contributors:

DSM MPS – GDS Associates
RFP – Sargent and Lundy
DSP – Internal & Conrad Technical Services
Load Forecast – Itron
PVRR Calculations – Concentric
Reliability Analysis – Quanta
IRP Modeling & Evaluation – Internal with ACES & Anchor Power support

Meeting #2 Recap: Portfolio Matrix Update

Strategies & Scenarios for Scorecard Evaluation

Combining Strategies and Scenarios results in the Portfolio Matrix or framework for IRP evaluation:

		Scenarios			
		No Environmental Action	**Current Trends (Reference Case)**	**Aggressive Environmental**	**Decarbonized Economy**
Generation Strategies	**No Early Retirement**				
	Pete Refuel to 100% Gas (est. 2025)				
	One Pete Unit Retires (2026)				
	Both Pete Units Retire (2026 & 2028)				
	"Clean Energy Strategy" Both Pete Units Retire and Replaced with Wind, Solar & Storage (2026 & 2028)				
	Encompass Optimization without predefined Strategy				

Portfolio cost (PVRR) will be calculated for each portfolio to complete Portfolio Matrix

- The Current Trends portfolios defined above will be evaluated using a Scorecard that includes cost, environmental, reliability & risk metrics.
- A Preferred Resource Portfolio will be selected using this rigorous Scorecard evaluation process.

Other Updates from Meeting #2

1) Energy Efficiency Bundles

- After stakeholder collaboration AES Indiana decided to split Efficient Products and Residential Vintage 2 & 3 into higher and lower cost bundles to provide the opportunity for additional cost-effective energy efficiency to get selected.

BEFORE

	Vintage 1 2024 - 2026	Vintage 2 2027 - 2029	Vintage 3 2030 - 2042
Residential	Efficient Products	All Residential (excluding IQW)	All Residential (excluding IQW)
	Behavioral		
	School Education		
	Appliance Recycling		
	Multifamily		
	*IQW	*IQW	*IQW
C&I	Prescriptive	All C&I	All C&I
	Custom		
	Custom RCx		
	Custom SEM		

*IQW Program will be predefined in the IRP modeling

AFTER

	Vintage 1 2024 - 2026	Vintage 2 2027 - 2029	Vintage 3 2030 - 2042
Residential	Efficient Products - Lower Cost	Lower Cost Residential (excluding IQW)	Lower Cost Residential (excluding IQW)
	Efficient Products - Higher Cost		
	Behavioral		
	School Education	Higher Cost Residential (excluding IQW)	Higher Cost Residential (excluding IQW)
	Appliance Recycling		
	Multifamily		
	*IQW	*IQW	*IQW
C&I	Prescriptive	All C&I	All C&I
	Custom		
	Custom RCx		
	Custom SEM		

*IQW Program will be predefined in the IRP modeling

2) Petersburg 3 & 4 Refuel Cost Updates

- Estimated capital costs for Petersburg Units 3 & 4 refuel to natural gas presented in Advisory Meeting 2 (April 12, 2022) have been refined.
- Estimated capital cost (excluding gas infrastructure upgrade) is ~$160/kW
- Capital expenditure still based on cost to refuel Harding Street units 5, 6, 7

2022 All-Source RFP & Replacement Resource Costs Update

Erik Miller, Manager, Resource Planning, AES Indiana

2022 All-Source Generation RFP

AES Indiana is conducting an All-Source RFP

- → Positions AES Indiana to efficiently procure generation consistent with final IRP Preferred Resource Portfolio
- → Informs IRP Replacement Resource Costs
- → RFP offers requested for Commercial Operation Date (COD) of 2025-2027
- → Projects leveraging Petersburg Unit 3 & 4 injection rights (~1,000MW) if retired through IRP process
- → RFP issued April 14, 2022
- → All proposals received by May 19, 2022

Department of Commerce Anti-Dumping/Countervailing Duties (AD/CVD) investigation

- → Initiated in March 2022 – DOC reviewing additional tariffs on solar panels manufactured in countries that are practicing improper biproduct disposal
- → Creates uncertainty for solar developers – current RFP offers include impacts from this uncertainty

*****Update*****

- → Biden Administration has issued Executive Order that waives the solar tariffs for 24 months
- → AES Indiana asking solar developers to refresh offers

Summary of All-Source RFP Responses

All projects received by May 19, 2022

- Eleven different developer respondents
- Total # of projects = 24
  - Total # of proposals = 140
- Prices higher than initial 2022 IRP replacement resource costs shared in Meeting #2 – with wide distribution in some categories
  - Currently tariff uncertainty, supply chain challenges and COVID impacts affecting prices – capturing this in IRP
  - Dynamic market conditions – subsequent RFP may result in lower prices

Technology	# of Projects
Solar	14
Wind	
Thermal-Aero CT	
Solar + Storage	
Storage	
TOTAL	24

****Confidential****
Competitively Sensitive Information

A <u>project</u> is defined as a unique site and each site may have multiple <u>proposal</u> offerings (PPA, Asset Transfer, etc.).

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All-Source RFP Capacity Summary

Key Proposal Summary:

- Total proposed installed capacity = ~4 GW
  - Proposed storage capacity = ~2.1 GW in both 4- and 6-hour durations
  - Robust amount of solar capacity = ~1.7 GW despite uncertainty around AD/CVD Tariffs
- Low volume of wind capacity possibly due to limited siting availability in Indiana and uncertainty around PTC
- Capacity volumes help to inform resource build constraints included in the IRP planning model (EnCompass)

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Commodity Forecasts

Erik Miller, Manager, Resource Planning, AES Indiana

IRP Commodity Price Updates

- AES Indiana initially used Horizon Energy Fall 2021 commodity price outlook for gas and coal to inform the custom fundamental power price studies performed by Horizon Energy.

- However – gas, coal and power prices have increased over the past few months –
  - In response to stakeholder comment and in order to ensure reasonable forecasts are included in this IRP – AES Indiana has had Horizon Energy update the custom fundamental power price studies using the Spring gas and coal price outlook. Thus, this IRP reflects the recent upward trend in gas, coal and power prices. The following commodity review slides reflect this update.

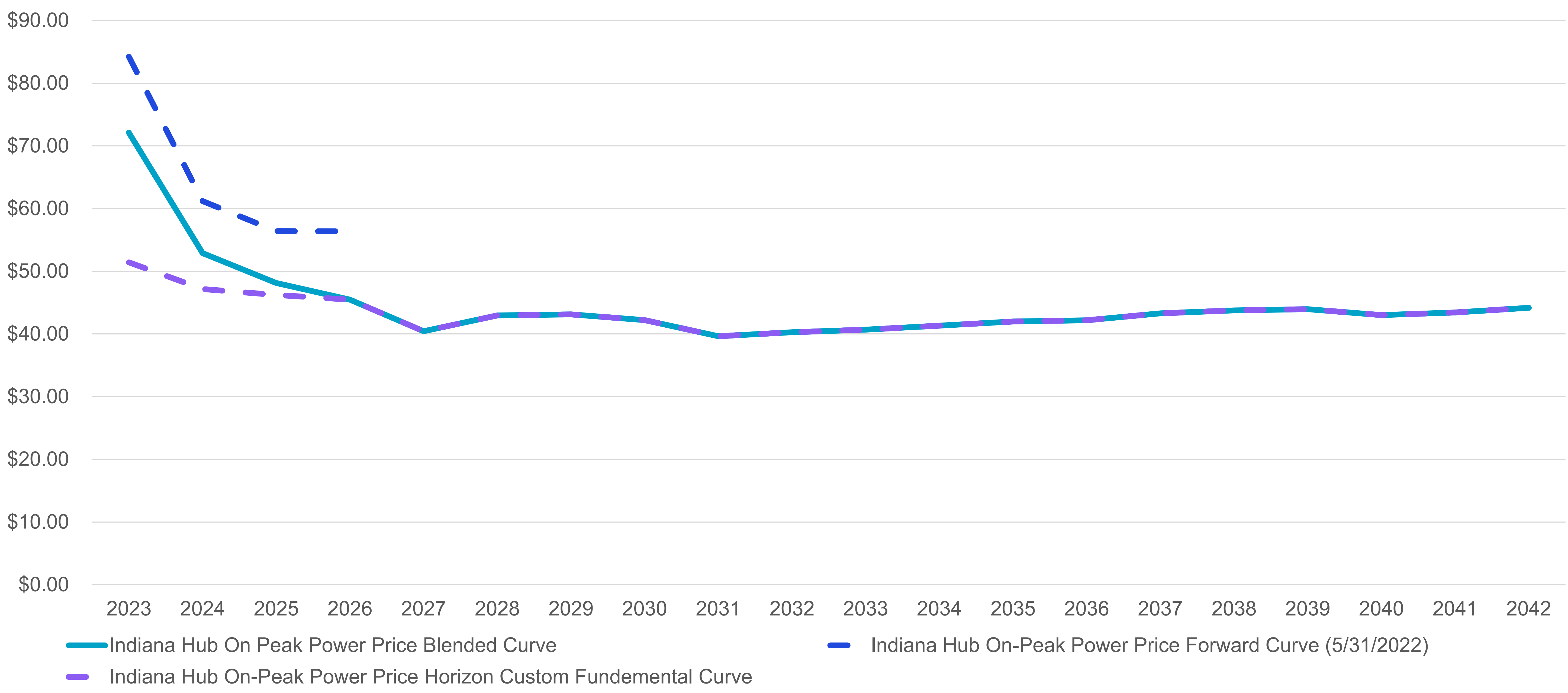
Summary of Scenario Commodity Assumptions

Scenario	Gas	Coal	Power	Capacity	NOx	CO_2
No Environmental Action – "No Env"	Low	Base	Custom	Base	Base	None
Current Trends (Reference Case) – "Ref"	Base	Base	Custom	Base	Base	Base
Aggressive Environmental – "AE"	High	Base	Custom	Base	High	High
Decarbonized Economy – "Decarb"	Base	Base	Custom	Base	High	None – Clean Energy Mandate

Methodology: Blending Curves

Power prices, gas prices and coal prices are a blend of forward market curves and Fundamental Curves from Horizon Energy.

Blending prices in near-term captures near-term market impacts.



Blending by Year

2023 = 40% Horizon Curve; 60% Forward Curve

2024 = 65% Horizon Curve; 35% Forward Curve

2025 = 85% Horizon Curve; 15% Forward Curve

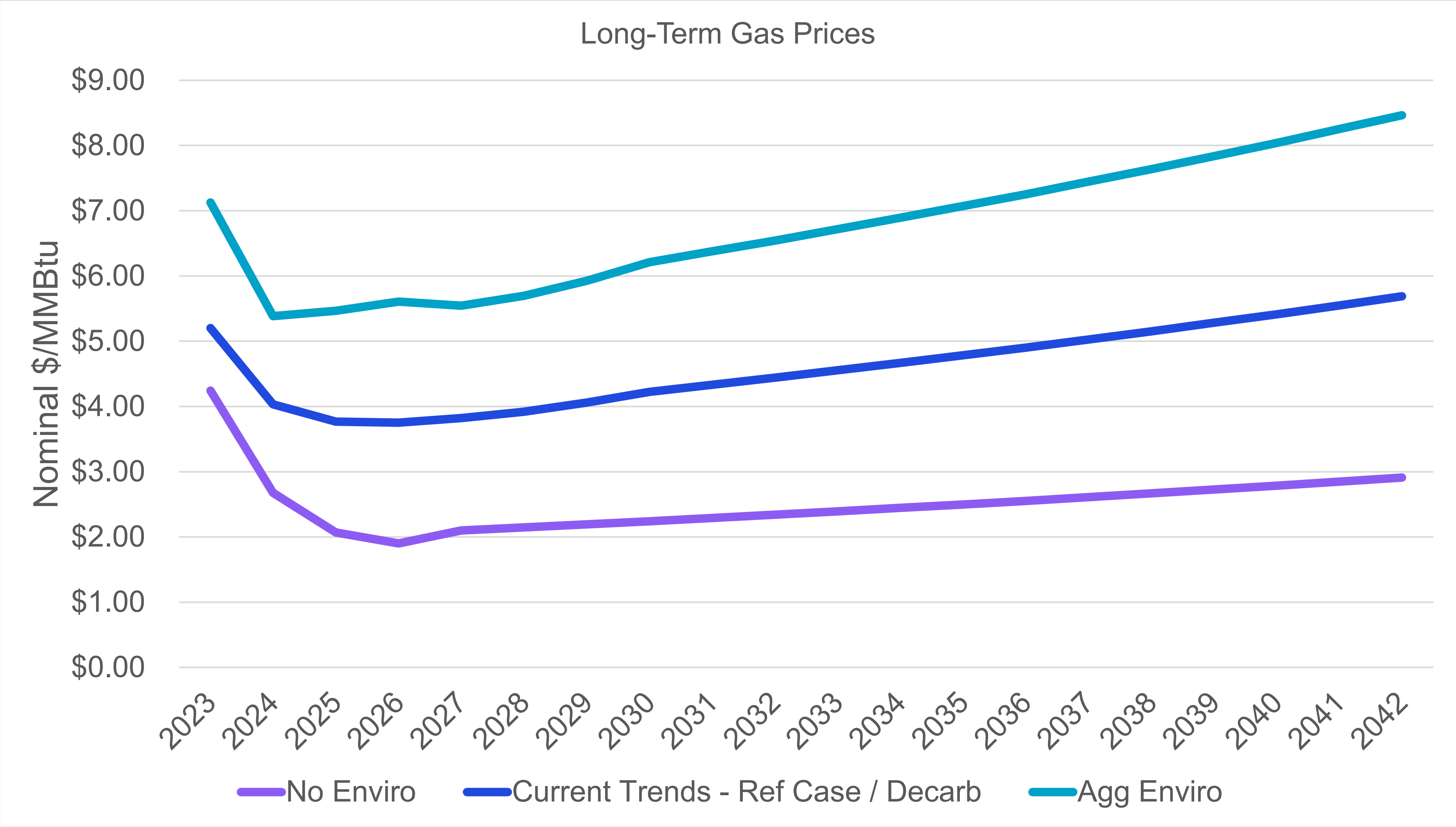
2026 – 2042 = 100% Horizon Curve

Fuel Price Forecasts

→ **Blended Long-term Gas Prices –**

→ 2023 – 2025 Blended: ICE Gas Forward Curve (5/31/2022) and Horizon 2022 Spring Case

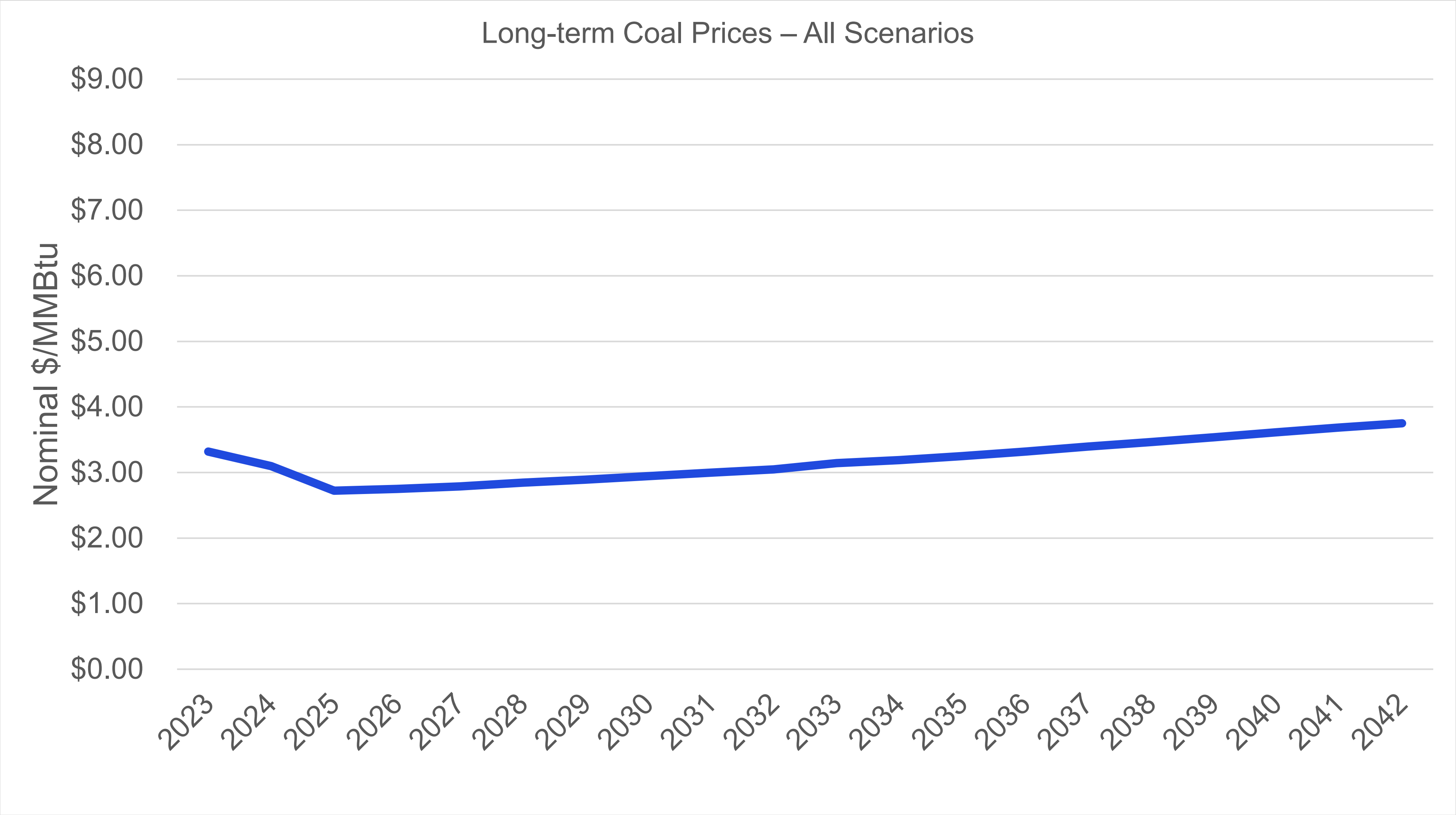
→ 2026 – 2042: Horizon 2022 Spring Case



→ **Blended Long-term Coal Prices –**

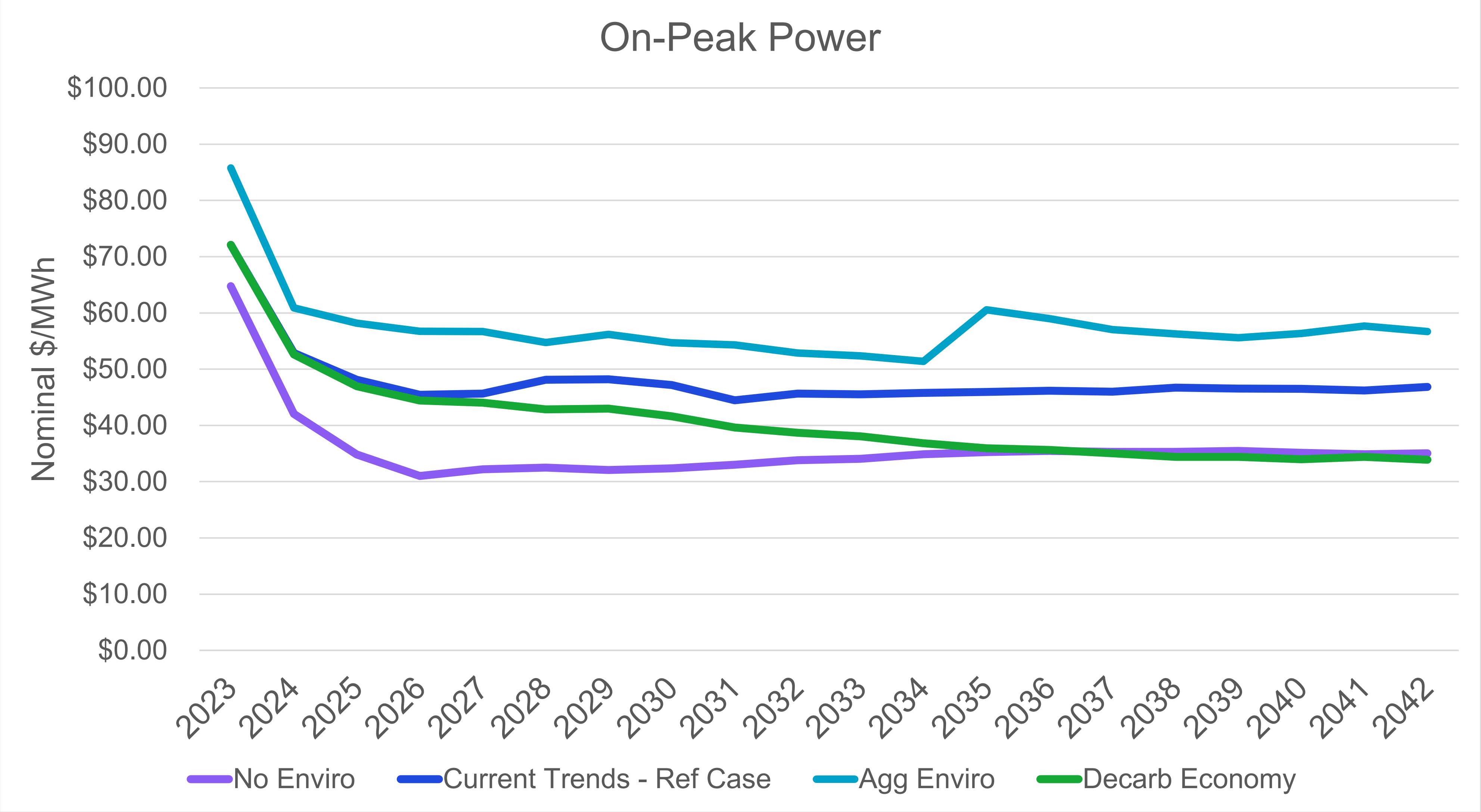
→ 2023 – 2025 Blended: Internal Mkt Intelligence,

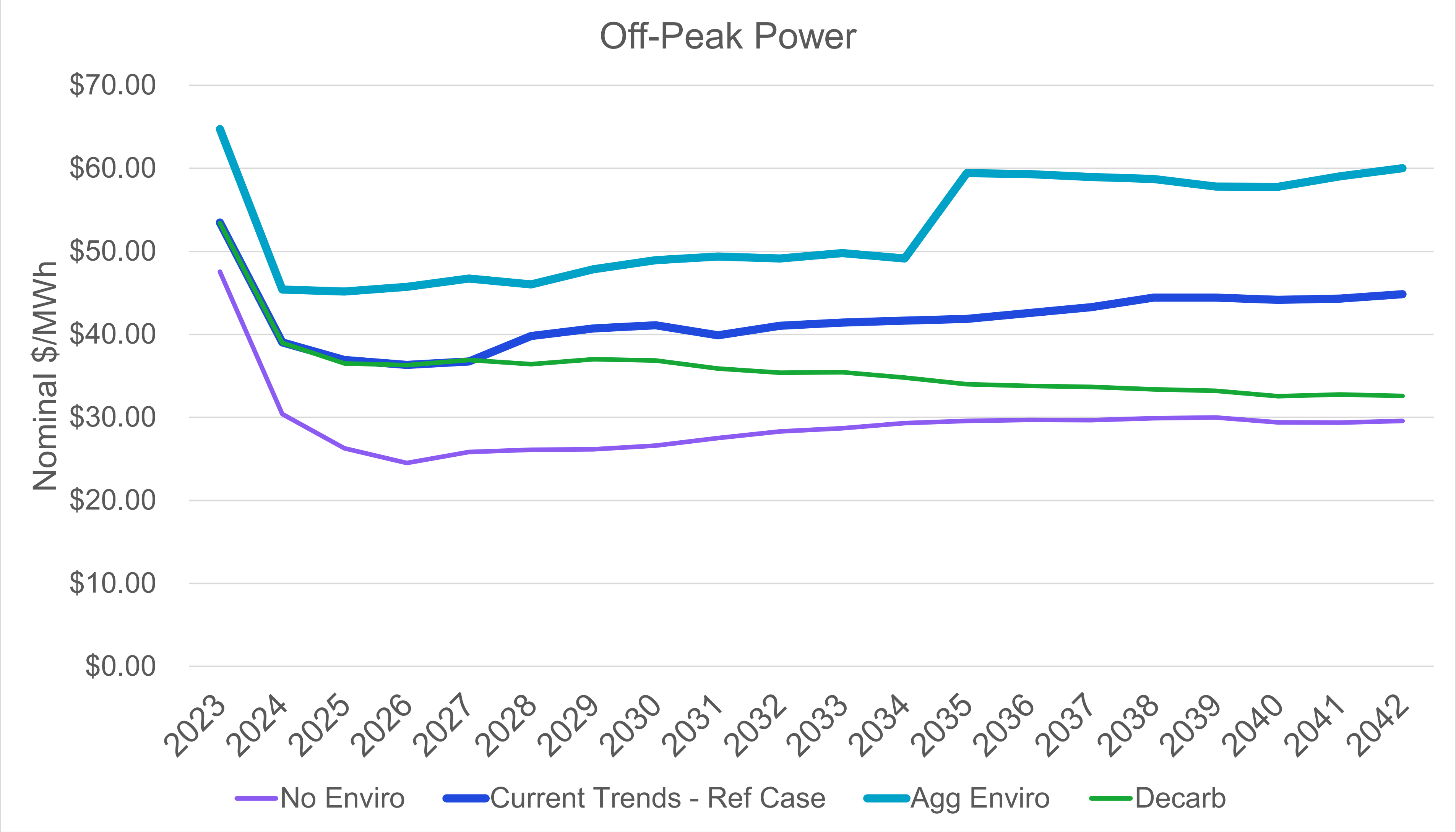
→ 2026 – 2042: Internal Mkt Intelligence with Horizon Energy Spring Case growth rate for Illinois Basin



Power Price Forecast

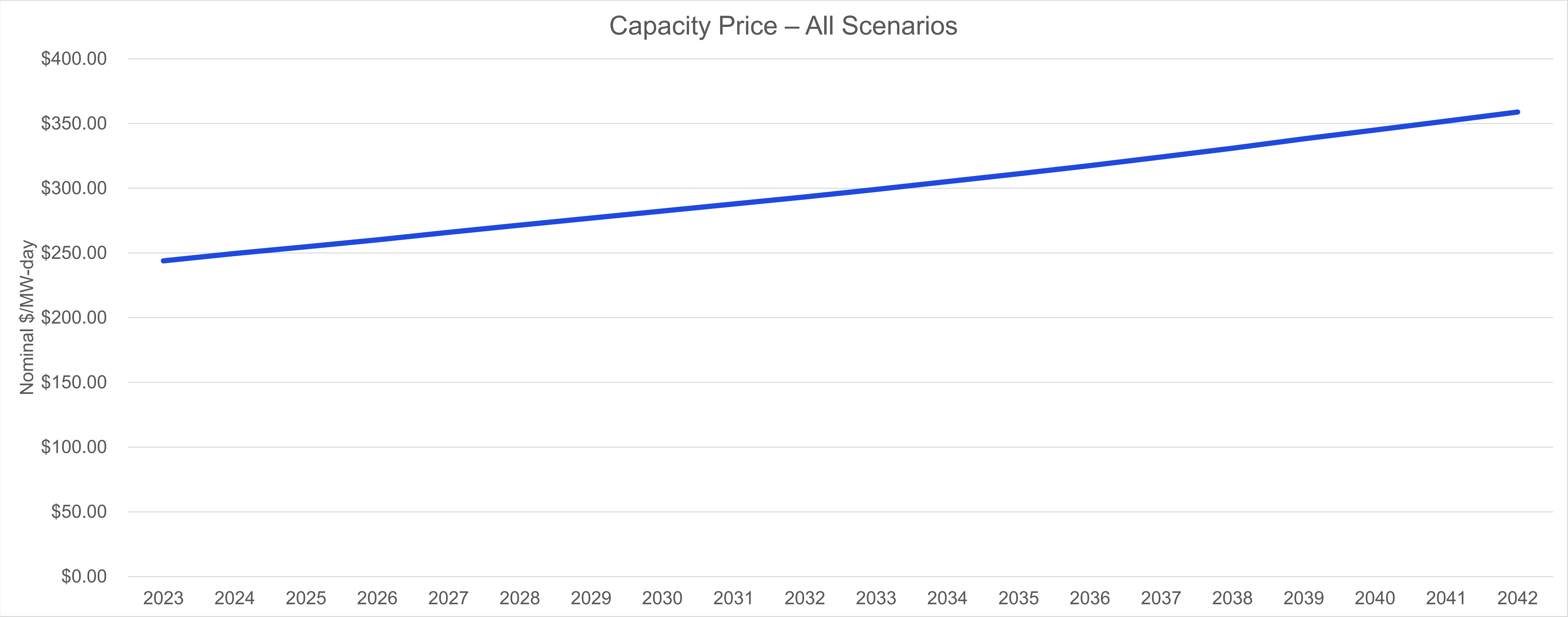
- **Blended Long-term Power Prices –**
  - 2023 – 2025 Blended: ICE Power Forward Curves 5/31/2022 and Horizon Energy Custom Fundamental Forecasts
  - 2026 – 2042: Horizon Energy Custom Fundamental Forecasts



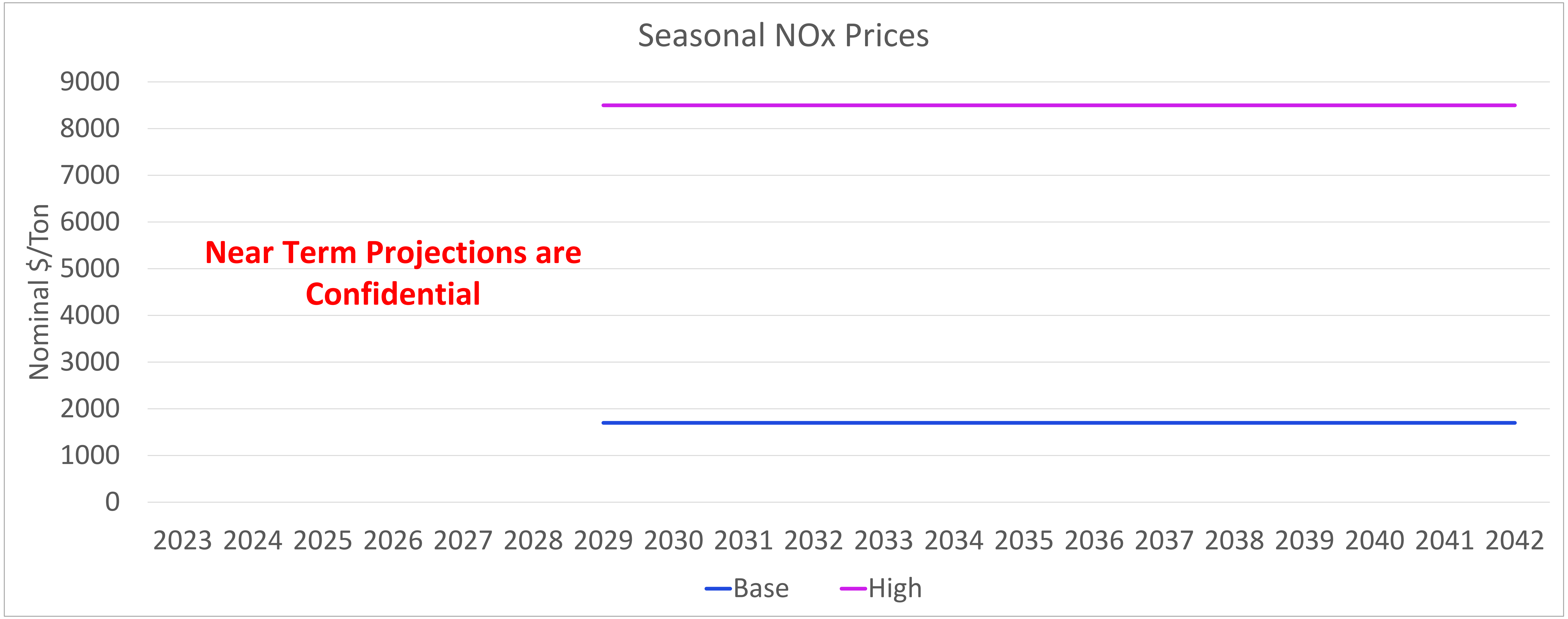


Capacity Price Forecast

- **Long-term Capacity Prices –**
  - 2023 – 2042: Cost of New Entry (CONE) captured in all four-seasons based on MISO Seasonal Capacity Construct



NOx Price Forecast



- **Base NOx** – forecast held flat at $1,700/ton from 2029 – 2042
- **High NOx** – forecast held flat at $8,500/ton from 2029 – 2042

RTO Reliability Planning: Resource Adequacy & Seasonal Construct

Lynn Hecker, Senior Manager, Resource Adequacy Policy and Analytics, MISO

Break for Lunch

Time	Topic	Speakers
Afternoon Starting at 12:30 PM	Modeling Reliability Assumptions	Erik Miller, Manager, Resource Planning, AES Indiana
	Reliability Analysis & Reliability Metric	Hisham Othman, VP Transmission and Regulatory Consulting, Quanta
	Portfolio Metrics & Scorecard	Erik Miller, Manager, Resource Planning, AES Indiana
	AES Indiana Distribution System Planning	Kathy Storm, Vice President, US Smart Grid, AES Indiana Mike Russ, Senior Manager, T&D Forecasting, AES Indiana
	Final Q&A and Next Steps	

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Modeling Reliability Assumptions

Erik Miller, Manager, Resource Planning, AES Indiana

Reliability Overview

As utilities retire and replace baseload generation with intermittent renewable generation, it has become **critical to ensure that customers receive energy during critical peak periods or system emergencies.**

In this IRP, AES Indiana will **measure and compare the reliability of the candidate portfolios in selecting a Preferred Resource Portfolio** that provides electricity safely, reliably, efficiently, and cost-effectively.

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The Importance of Measuring Reliability

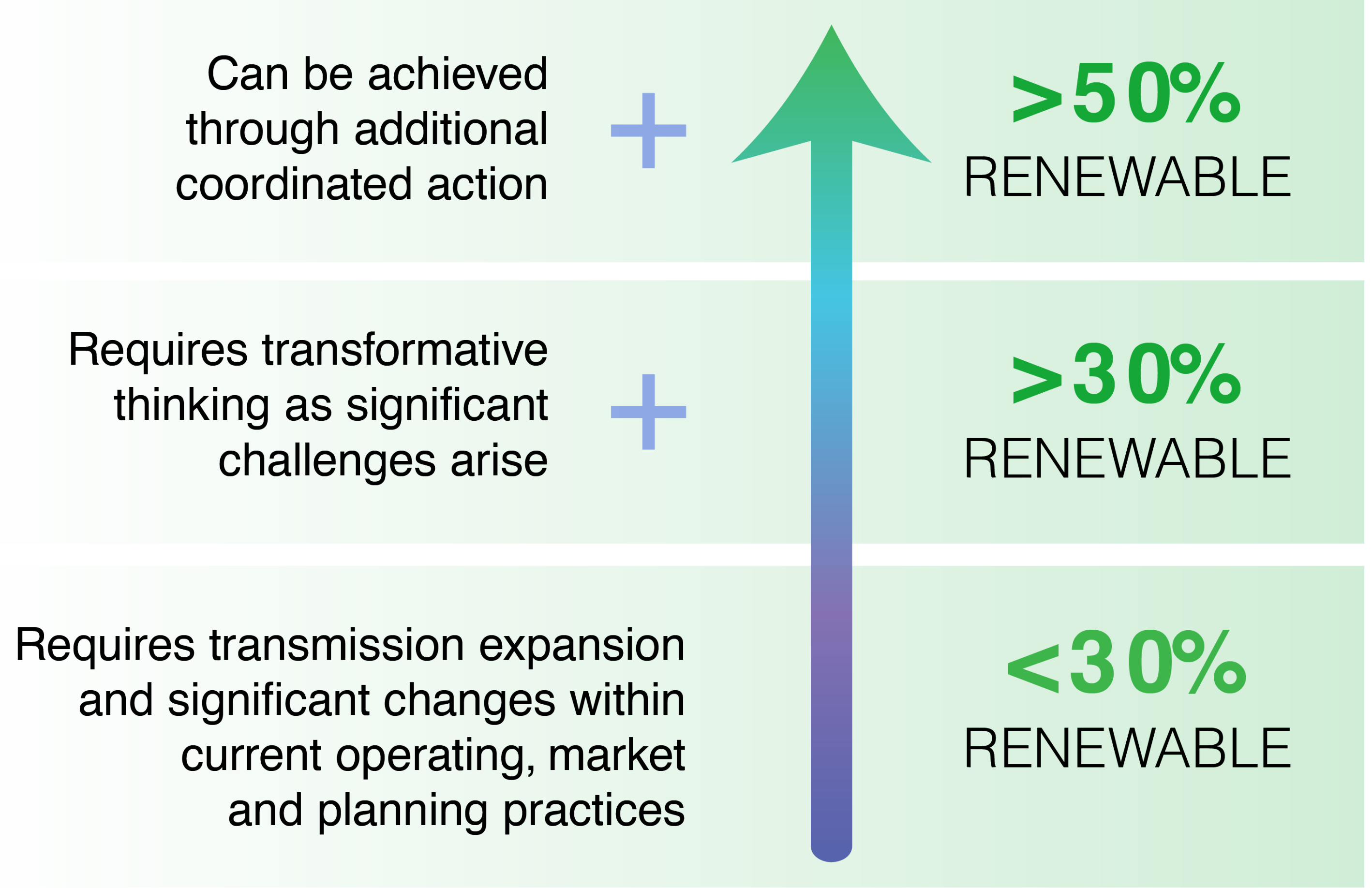
→ Guiding research on reliability

→ **MISO's Renewable Integration Impact Assessment (RIIA) – completed Feb 2021**

- MISO analysis to understand the bulk electric system needs and risks as intermittent renewable resources increasingly replace baseload resources.
- Analysis finds increasing risk and need for coordinated action as renewables increase to 30% and 50% of the MISO system portfolio.

→ **RIIA's three key areas of focus**

- The RIIA analysis suggests three key focus areas for MISO and stakeholders.
- **Utilities can consider two of the three within the context of the IRP.**



Topic	Definition	Planning Responsibility
1 **Resource Adequacy**	Having sufficient resources to reliably serve peak demand	AES Indiana will address in this IRP
2 **Energy Adequacy**	Ability to provide energy in all operating hours continuously throughout the year	AES Indiana will address in this IRP
3 **Operating Reliability**	Ability to withstand unanticipated component losses or disturbances	Joint coordination between AES Indiana and MISO

https://www.misoenergy.org/planning/policy-studies/Renewable-integration-impact-assessment/

Reliability in the IRP

1 Resource Adequacy: Having sufficient resources to reliably serve load

MISO Seasonal Resource Adequacy Construct

- On November 30, 2021 – MISO filed with FERC to include seasonal and accreditation requirements for the MISO Resource Adequacy Construct.
- Reason: Ensure resource adequacy across all seasons after significant increase in MaxGen events resulting from the retirement of baseload generation, increased intermittent resources and extreme weather events.
- MISO's proposed filing would require MISO member utilities to meet an unforced capacity requirement in each season as opposed to only Summer (current requirement).
- MISO has proposed these changes begin in the 2023/2024 planning year.

Planning Implications

- AES Indiana will model a four-season Resource Adequacy Construct starting in 2023/2024 to align with MISO's FERC filing.
- Per MISO guidance, AES Indiana will include these reserve margin targets in the IRP analysis:

Target Seasonal Planning Reserve Margin:

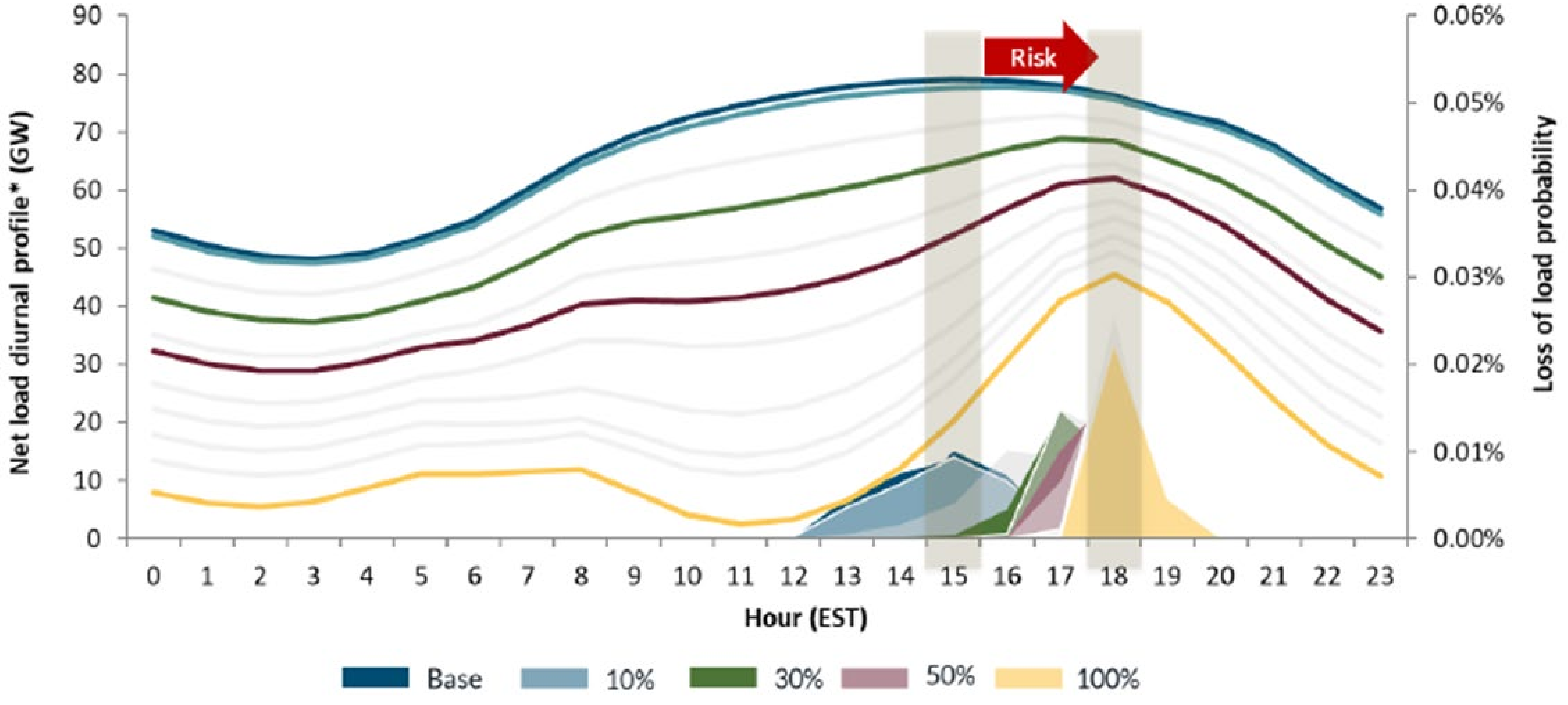
PRM% Summer	7.51%
PRM% Fall	11.82%
PRM% Winter	21.35%
PRM% Spring	26.27%

Reliability in the IRP

1 Resource Adequacy: Having sufficient resources to reliably serve load

Effective Load Carrying Capacity (ELCC) of Wind and Solar

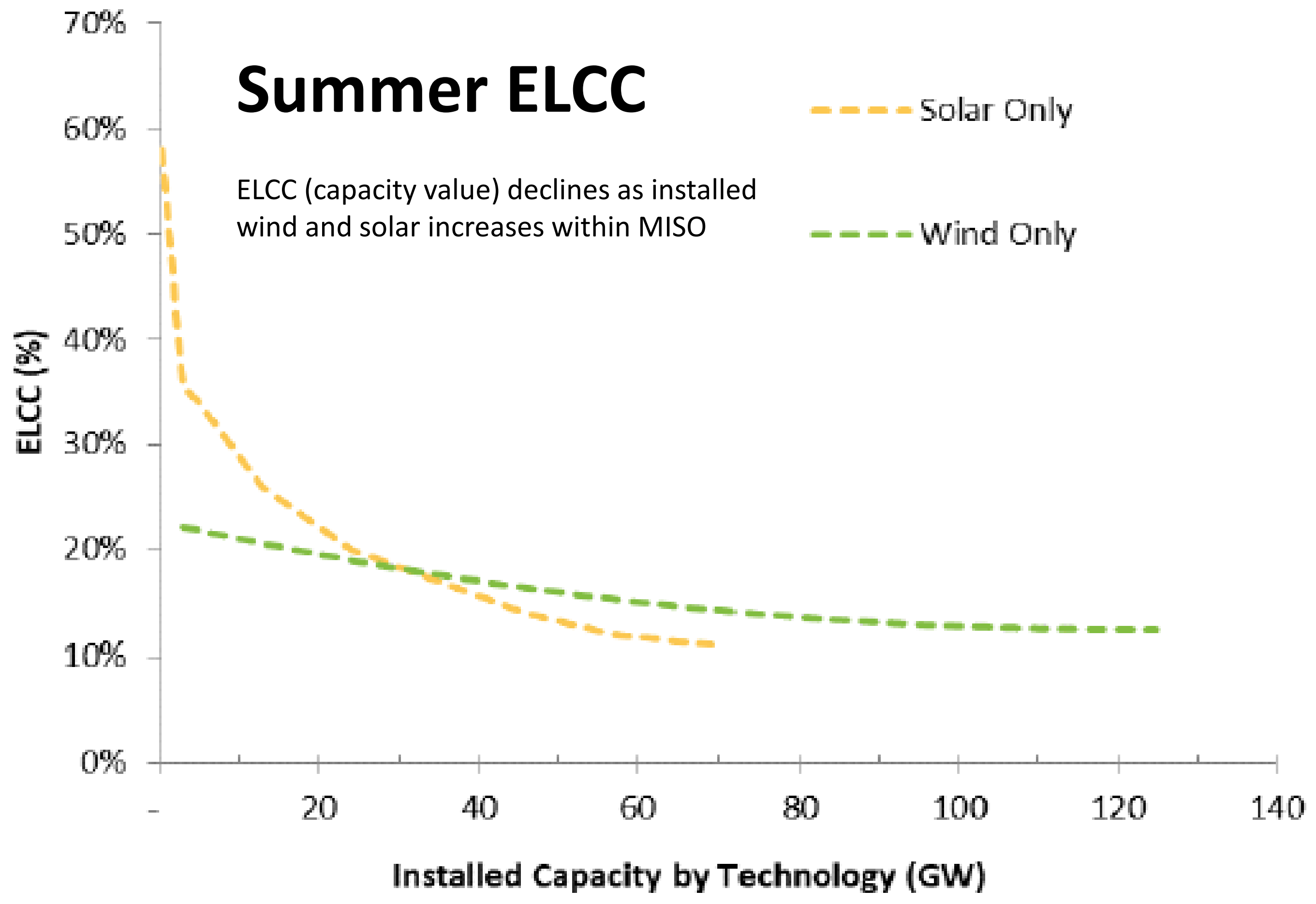
Shifting Peak: As the penetration of wind and solar increases within the MISO footprint, the availability of wind and solar resources during the new high risk period decreases.



*Charts from MISO RIIA Report pp.27 & 29

Planning Implications:

- The planning model will capture the changing availability of wind and solar through the ELCC, i.e. capacity value for wind and solar
- AES Indiana has consulted with MISO to understand the ELCC value for seasonal planning – Summer, Winter, Spring & Fall



****AES Indiana presented ELCC of wind, solar and storage resources in Public Stakeholder Meeting #2 – also provided in slide appendix of this deck****

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Reliability in the IRP

2 **Energy Adequacy:** Ability to provide energy in all operating hours continuously throughout the year

Production Cost Modeling (8,760)

- As part of the core IRP modeling, AES Indiana will perform a production cost analysis on each candidate portfolio.
- The analysis provides an understanding of economic energy adequacy or how much AES Indiana will rely on the market for sales and purchases.

System Reliability Analysis

- AES Indiana contracted Quanta Energy to perform a System Reliability Analysis as part of the IRP Scorecard evaluation.
- The analysis looks at eight system metrics with the objective of evaluating how well the candidate portfolios deliver sufficient energy and system stability in every hour.
- **Quanta Energy will review the methodology for the System Reliability Analysis in the slides that follow.**

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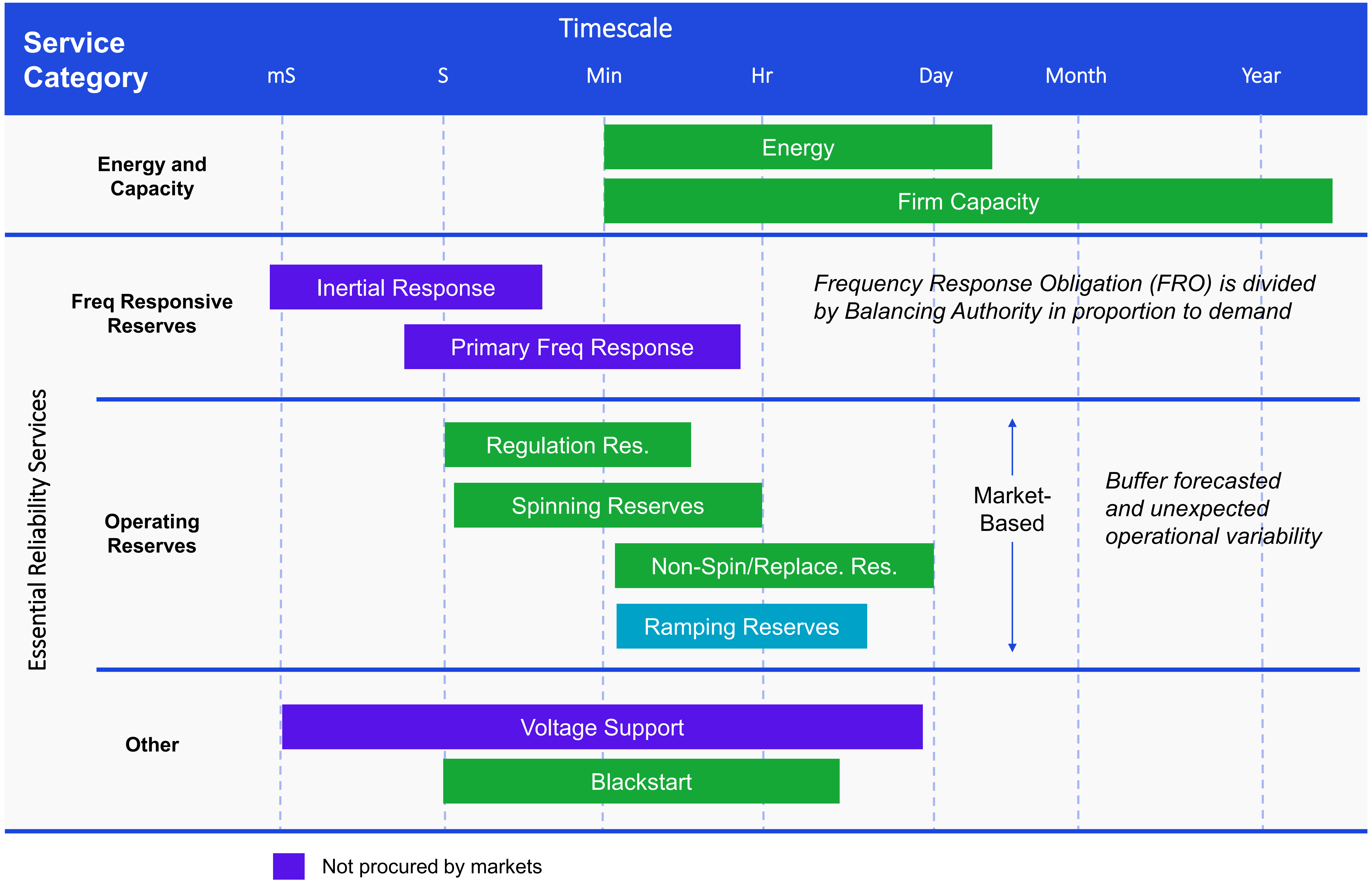
Reliability Analysis

Hisham Othman, VP Transmission and Regulatory Consulting, Quanta

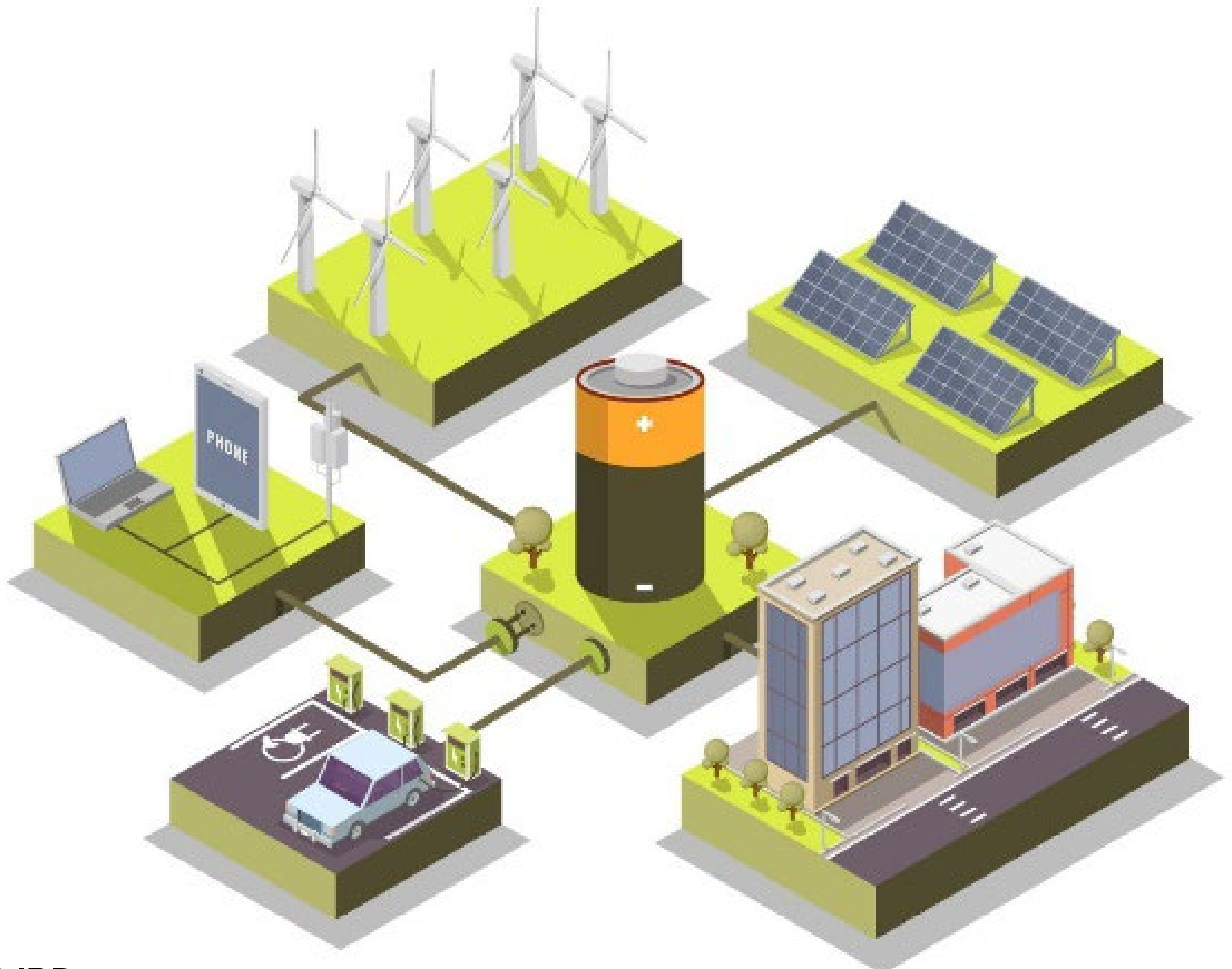
Essential Reliability Services



- Power systems rely on several reliability services to operate and deliver expected services. Some have traditionally been assumed to be provided by the supply resources, while others are procured by the market. As the resource portfolio changes, the associated essential reliability services should be assessed and secured.
- **NERC (2022 Summer Reliability Assessment – MISO):**
  - Midcontinent ISO (MISO) faces a capacity shortfall in its North and Central areas, resulting in high risk of energy emergencies during peak summer conditions.
  - More extreme temperatures, higher generation outages, or low wind conditions expose the MISO North and Central areas to higher risk of temporary operator-initiated load shedding to maintain system reliability.
- **PJM (Grid of the Future - May 2022):**
  - A proliferation of IBRs can significantly impact reactive control, stability, short-circuit current, inertia and frequency control – all critical dimensions of future grid planning.

Resource Reliability Attributes

- **Resources have many attributes aside from energy and capacity that are critical to reliable operation.**
  - Selecting a portfolio with the right attributes is crucial to ensure reliability and resilience.
  - Portfolio evaluation should account for their reliability attributes.
  - System needs for reliability attributes increases with higher levels of inverter-based resources (IBRs).

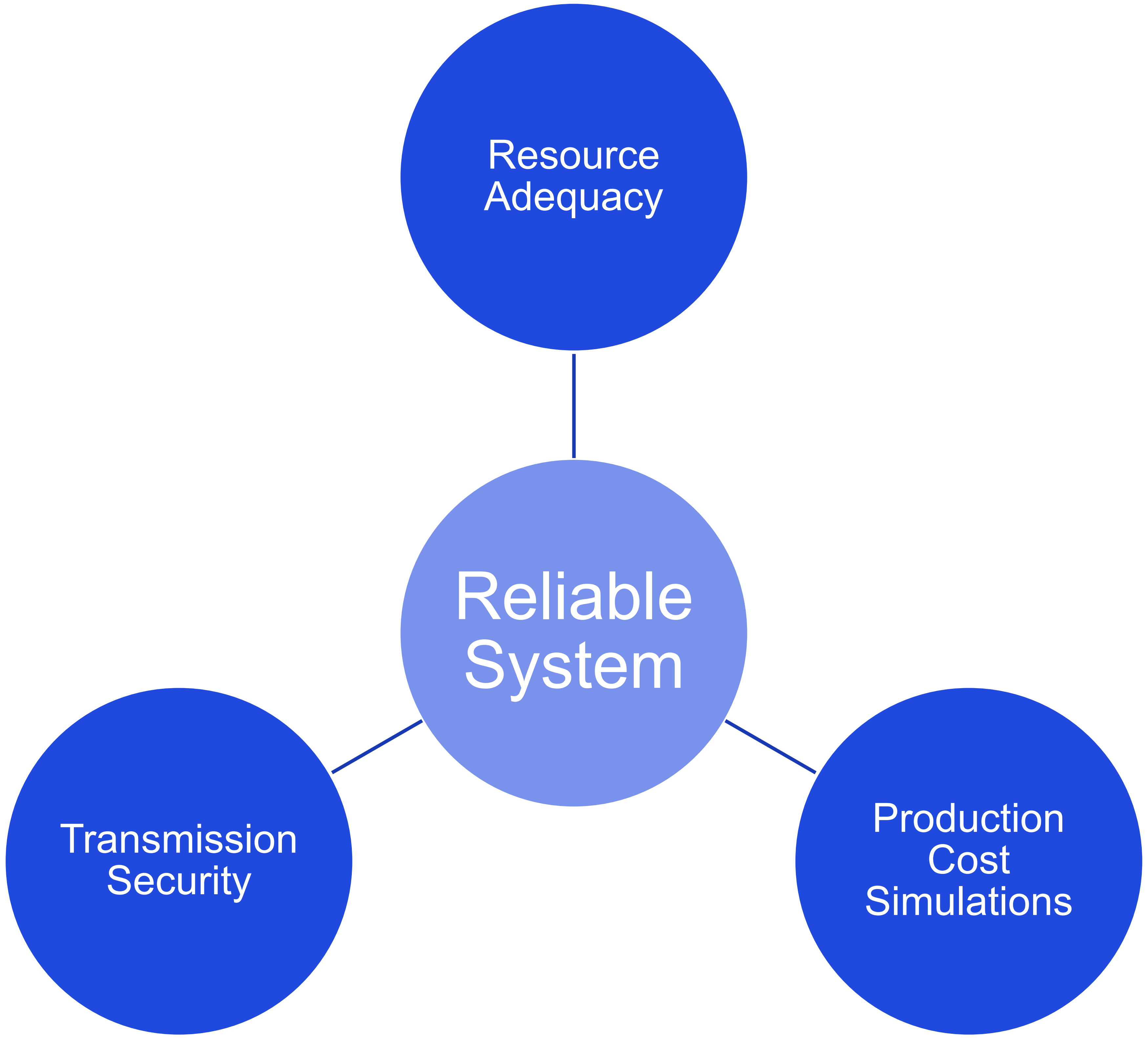


- **Reliability and Resilience Attributes/Metrics:**
  - Dispatchability
  - Predictability
  - Dependability (e.g., Supply Resilience, firmness)
  - Performance Duration Limits
  - Flexibility (e.g., ramping speed, operating range)
  - Intermittency (e.g., intra-hour and multi-hour ramping)
  - Dynamic VAR support
  - Energy Profile (e.g., capacity value / ELCC)
  - Inertial Response
  - Primary Frequency Response
  - Minimum Short Circuit Ratio
  - Locational Characteristics (e.g., deliverability, resilience to grid outages)
  - Blackstart and system restoration support
  - Harmonics

Assuring System Reliability – Traditional Approach

- **Traditional planning ensures provision of sufficient generation and transmission capacity, based on:**
  - Centralized synchronous generation
  - Dispatchable resources
  - Predictable flow patterns
  - Excludes fuel constraints
  - Few operating snapshots
  - Separate T and D planning

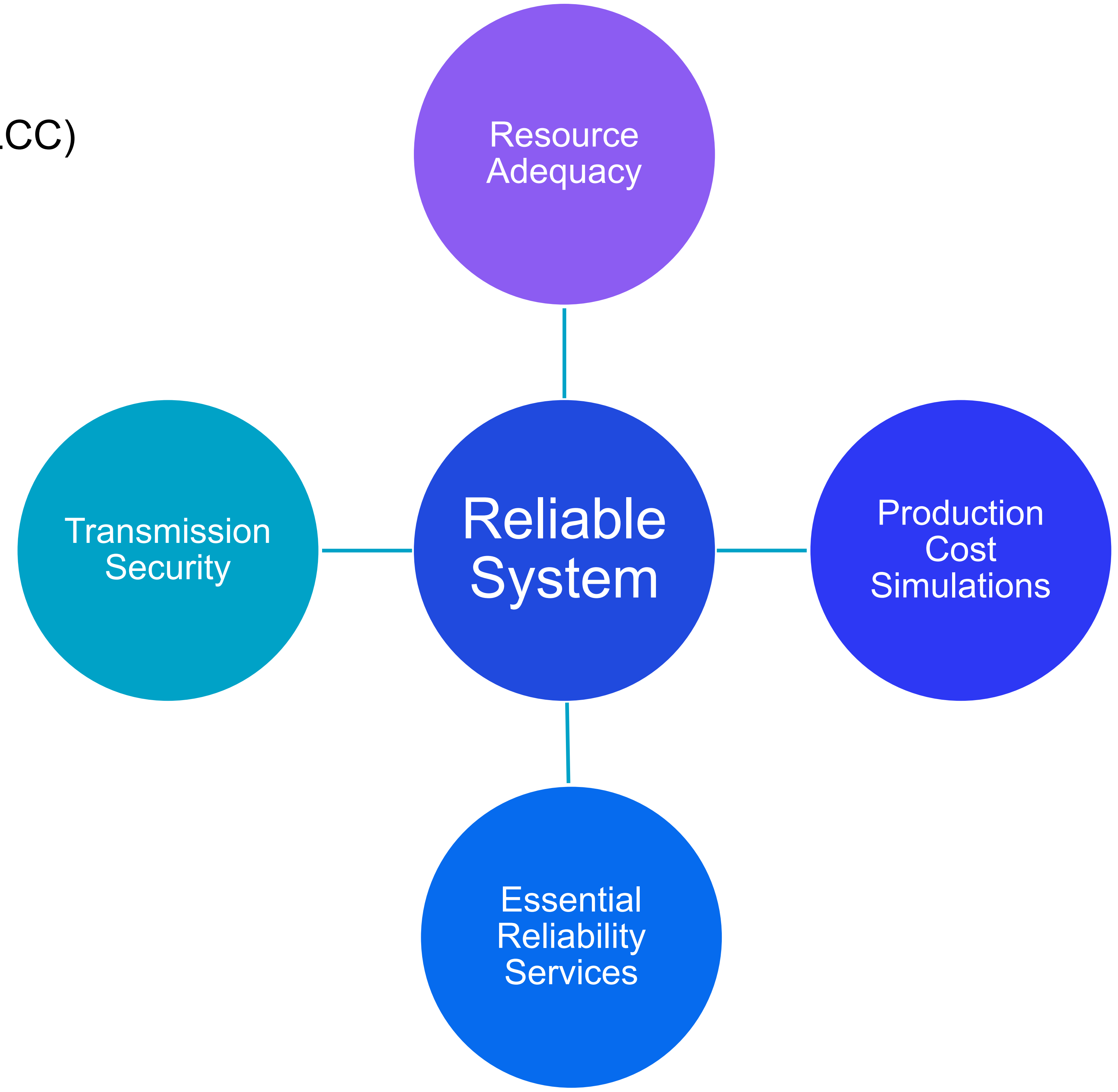
- However, with increasing retirements and dependance on solar/wind/storage resources, distributed and utility-scale, this planning paradigm is not sufficient to assure operational reliability.



Assuring System Reliability – Evolving Approaches

- **Traditional planning methods are evolving:**
  - Resource Adequacy: Seasonal Construct & Effective Load Carrying Capability (ELCC)
  - Time-series transmission security (8760 hours)
  - Stochastic production cost simulations (renewable/load profiles)
  - Integrated T&D planning
  - Scenario planning approaches to address increased uncertainty

- **More analysis is required - Essential Reliability Services:**
  - 1. Energy Adequacy
  - 2. Operational Flexibility and Frequency Support
  - 3. Short Circuit Strength Requirement
  - 4. Power Quality (Flicker)
  - 5. Blackstart
  - 6. Dynamic VAR Deliverability
  - 7. Dispatchability and Automatic Generation Control
  - 8. Predictability and Firmness of Supply
  - 9. Geographic Location Relative to Load



Reliability Assessment & Portfolio Eval. Methodology

Review & Update Reliability Metrics

	Criteria	Description	Rationale
1	Blackstart	Resource has the ability to be started without support from the wider system or is designed to remain energized without connection to the remainder of the system, with the ability to energize a bus, supply real and reactive power, frequency and voltage control	In the event of a black out condition, Must have a blackstart plan to restore its local electric system. The plan can either rely on ISO/RTO to energize a cranking path or on internal resources within the service territory.
2	Energy Adequacy	Resources are able to meet the energy and capacity duration requirements. Portfolio resources are able to supply the energy demand of customers during MISO's emergency max gen events, and also to supply the energy needs of critical loads during islanded operation events.	Must have long duration resources to serve the needs of its customers during emergency and islanded operation events.
3	Dispatchability and Automatic Generation Control	The unit will respond to directives from system operators regarding its status, output, and timing. The unit has the ability to be placed on Automatic Generation Control (AGC) allowing its output to be ramped up or down automatically to respond immediately to changes on the system.	ISO/RTO provides dispatch signals under normal conditions, but utility requires AGC attributes under emergency restoration procedures or other operational considerations
4	Operational Flexibility and Frequency Support	Ability to provide inertial energy reservoir or a sink to stabilize the system. The resource can adjust its output to provide frequency support or stabilization in response to frequency deviations with a droop of 5% or better	ISO/RTO provides market construct under normal conditions, but preferable that utility possess the ability to maintain operation during under-frequency conditions in emergencies
5	VAR Support	The resource can be used to deliver VARs out onto the system or absorb excess VARs and so can be used to control system voltage under steady-state and dynamic/transient conditions. The resource can provide dynamic reactive capability (VARs) even when not producing energy. The resource must have Automatic voltage regulation (AVR) capability. The resource must have the capability ranging from 0.85 lagging (producing) to 0.95 leading (absorbing) power factor	Must retain resources electrically close to load centers to provide this attribute in accordance with NERC and IEEE Standards
6	Geographic Location Relative to Load	The resource will be located in utility footprint (electric Transmission Operator Area) near existing 138kV pr 345kV facilities and is not restricted by fuel infrastructure. The resource can be interconnected at 138kV or 345kV. Preferred locations are ones that have multiple power evacuation/deliverability paths and are close to major load centers.	ISO/RTO requires location capacity resources and runs an LMP market to provide locational energy signals; under emergency restoration procedures, a blackstart plan reliant on external resources would create a significant risk. Location provides economic value in the form of reduced losses, congestion, curtailment risk, and address local capacity requirements. Additionally, from a reliability perspective, resources that are interconnected to buses with multiple power evacuation paths and those close to load centers are more resilient to transmission system outages and provide better assistance in the blackstart restoration process.
7	Predictability and Firmness of Supply	Ability to predict/forecast the output of resources and to counteract forecast errors.	Energy is scheduled with ISO/RTO in the day-ahead hourly market and in the real-time 5-minute market. Deviations from these schedules have financial consequences and thus the ability to accurately forecast the output of a resource up to 38 hours ahead of time for the day-ahead market and 30 minutes for the real time market is advantageous.
8	Short Circuit Strength Requirement	Ensure the strength of the system to enable the stable integration of all inverter-based resources (IBRs) within a portfolio.	The retirement of synchronous generators within utility footprint and also within ISO/RTO and replacements with increasing levels of inverter-based resources will lower the short circuit strength of the system. Resources than can operate at lower levels of SCR and those that provide higher short circuit current provide a better future proofing without the need for expensive mitigation measures.

Assemble Data and Configure Analysis Tools

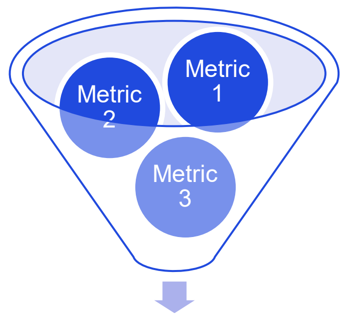
- Existing Resources
- IRP Portfolios
- Grid Models
- Solar & Wind Profiles
- Load Profile
- Transfer Capability with Outside

Apply a Series of Reliability Filters to IRP Portfolios

- 1. Energy Adequacy
- 2. Flexibility & Frequency Response
- 3. Short Circuit Strength
- 4. Power Quality (Flicker)
- 5. Blackstart
- 6. Dynamic VAR Deliverability
- 7. Dispatchability
- 8. Predictability and Supply Firmness
- 9. Geographic Location

Design Scoring Criteria

Evaluate Portfolios



Portfolio Score

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Indicative Scope of Reliability Studies

	Reliability Study Area	Normal (50/50, Connected)	Max-Gen (90/10, Import Limited)	Islanded (Critical Load)
-	Resource Adequacy	X (also 90/10)		
-	Energy Adequacy	X (8760)		
-	Transmission Reliability / Deliverability / Interconnections	X		
1	Energy Adequacy		X	X
2	Operational Flexibility and Frequency Support	X		X
3	Short Circuit Strength Requirement	X		X
4	Power Quality (Flicker)	X		
5	Blackstart			X
6	Dynamic VAR Deliverability	X		
7	Dispatchability and Automatic Generation Control	X		
8	Predictability and Firmness of Supply	X		
9	Geographic Location Relative to Load	X		

→ Typically, Part of IRP Portfolio Design

→ Additional Reliability Analysis

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Reliability Metrics (1/2)

	Metric	Description	Rationale
1	**Energy Adequacy**	Resources are able to meet the energy and capacity duration requirements. Portfolio resources are able to supply the energy demand of customers during normal and emergency max gen events, and also to supply the energy needs of critical loads during islanded operation events.	Utility must have long duration resources to serve the needs of its customers during emergency and islanded operation events.
2	**Operational Flexibility and Frequency Support**	Ability to provide inertial energy reservoir or a sink to stabilize the system. Additionally, resources can adjust their output to provide frequency support or stabilization in response to frequency deviations with a droop of 5% or better.	Regional markets and/or control centers balance supply and demand under different time frames according to prevailing market construct under normal conditions, but preferable that local control centers possess the ability to maintain operation during under-frequency conditions in emergencies.
3	**Short Circuit Strength Requirement**	Ensure the strength of the system to enable the stable integration of all inverter-based resources (IBRs) within a portfolio.	The retirement of synchronous generators within utility footprint and replacements with increasing levels of inverter-based resources will lower the short circuit strength of the system. Resources that can operate at lower levels of short circuit ratio (SCR) and those that provide higher short circuit current provide a better future proofing without the need for expensive mitigation measures.
4	**Power Quality (Flicker)**	The "stiffness of the grid" affect the sensitivity of grid voltages to the intermittency of renewable resources. Ensuring the grid can deliver power quality in accordance with IEEE standards is essential.	Retirement of large thermal generation plants lower the strength of the grid and increases its susceptibility to voltage flicker due to intermittency of renewable resources, unless properly assessed and mitigated.
5	**Blackstart**	Ensure that resources have the ability to be started without support from the wider system or are designed to remain energized without connection to the remainder of the system, with the ability to energize a bus, supply real and reactive power, frequency and voltage control	In the event of a black out condition, utility must have a blackstart plan to restore its local electric system. The plan should demonstrate the ability to energize a cranking path to start large flexible resources with sufficient energy reservoir.
6	**Dynamic VAR Support**	Customer equipment driven by induction motors (e.g., air conditioning or factories) requires dynamic reactive power after a grid fault to avoid stalling. The ability of portfolio resources to provide this service depends on their closeness to the load centers.	Utility must retain resources electrically close to load centers to provide this attribute in accordance with NERC and IEEE Standards

Reliability Metrics (2/2)

	Metric	Description	Rationale
7	**Dispatchability and Automatic Generation Control**	Resources should respond to directives from system operators regarding their status, output, and timing. Resources that can be ramped up and down automatically to respond immediately to changes in the system contribute more to reliability than resources which can be ramped only up or only down, and those in turn are better than ones that cannot be ramped.	Ability to control frequency is paramount to stability of the electric system and the quality of power delivered to customers. Control centers (regional or local) provide dispatch signals under normal conditions, and under emergency restoration procedures or other operational considerations.
8	**Predictability and Firmness of Supply**	Ability to predict/forecast the output of resources and to counteract forecast errors.	The ability to predict resource output from a day-ahead to real-time is advantageous to minimize the need for spinning reserves. In places with an active energy market, energy is scheduled with the market in the day-ahead hourly market and in the real-time 5-minute market. Deviations from these schedules have financial consequences and thus the ability to accurately forecast the output of a resource up to 38 hours ahead of time for the day-ahead market and 30 minutes for the real time market is advantageous.
9	**Geographic Location Relative to Load (Resilience)**	Ensure the ability to have redundant power evacuation or deliverability paths from resources. Preferrable to locate resources at substations with easy access to multiple high voltage paths, unrestricted fuel supply infrastructure, and close to major load centers.	Location provides economic value in the form of reduced losses, congestion, curtailment risk, and address local capacity requirements. Additionally, from a reliability perspective, resources that are interconnected to buses with multiple power evacuation paths and those close to load centers are more resilient to transmission system outages and provide better assistance in the blackstart restoration process.

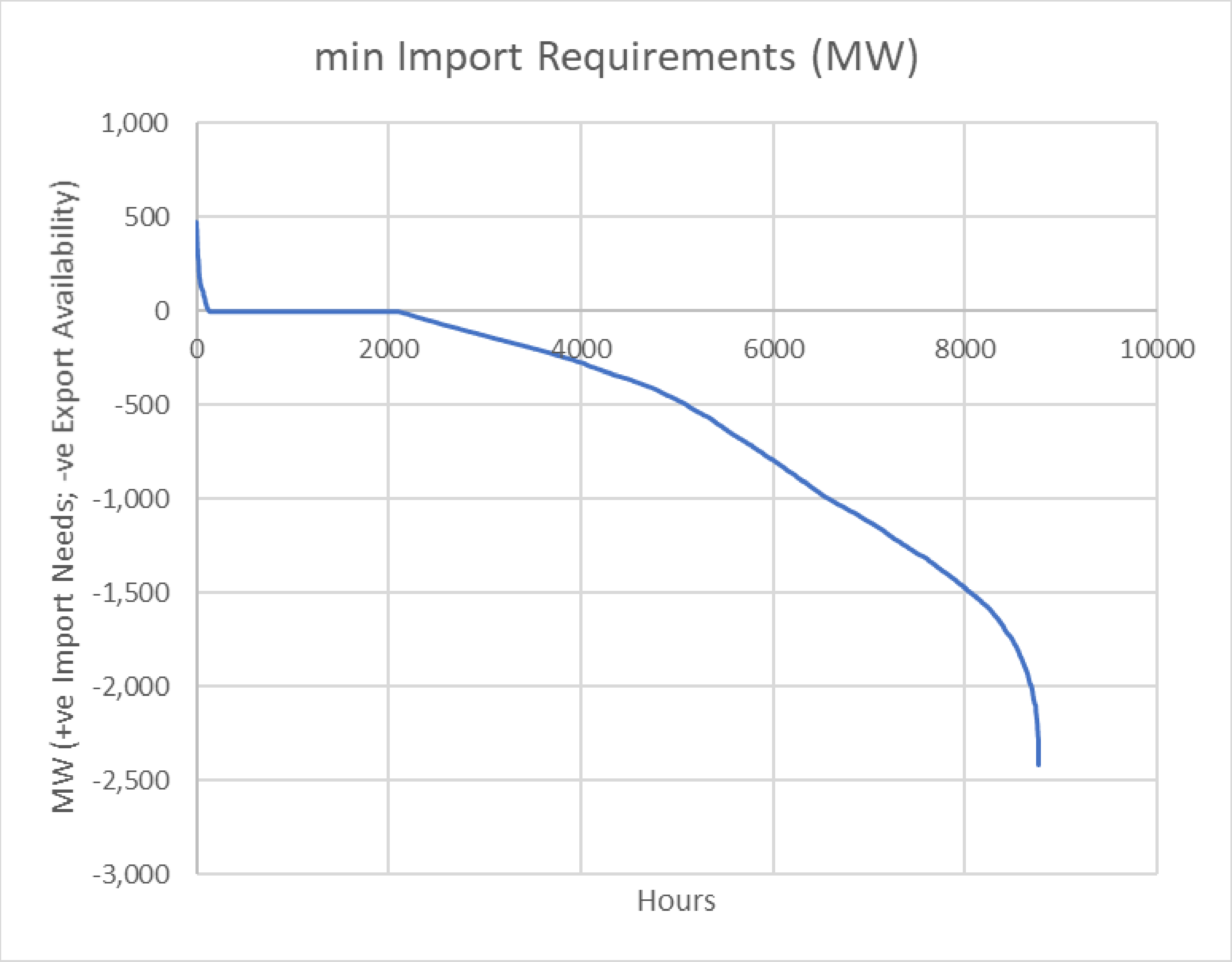
Sample Analysis

The following are illustrative sample analyses, not related to AES-Indiana system or portfolios.

(1) Energy Adequacy during Market Emergency Events

Illustrative sample analyses, not related to AES-Indiana system or portfolios

→ Example: Portfolio P1 (using 50/50 Load Forecast)

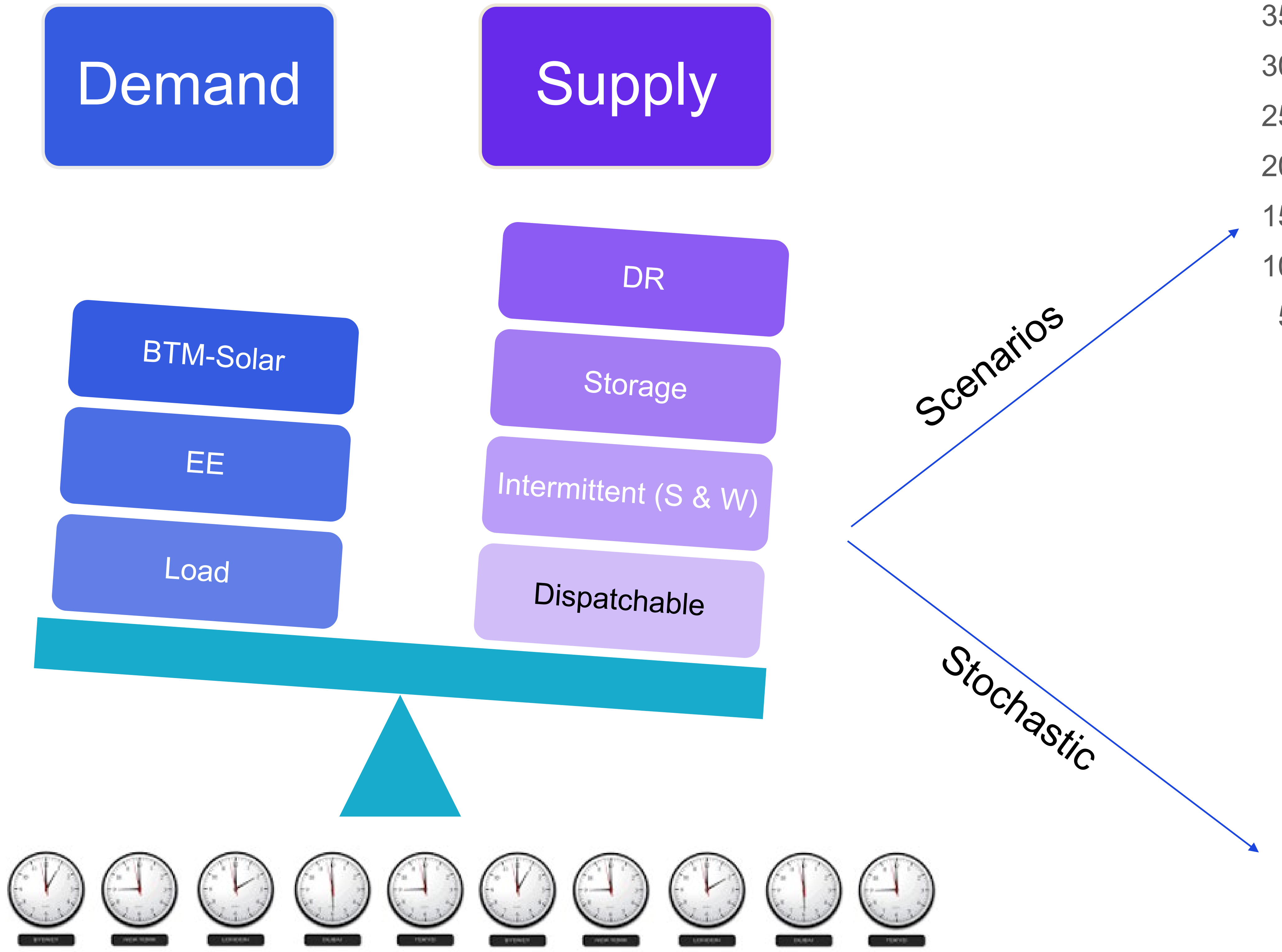


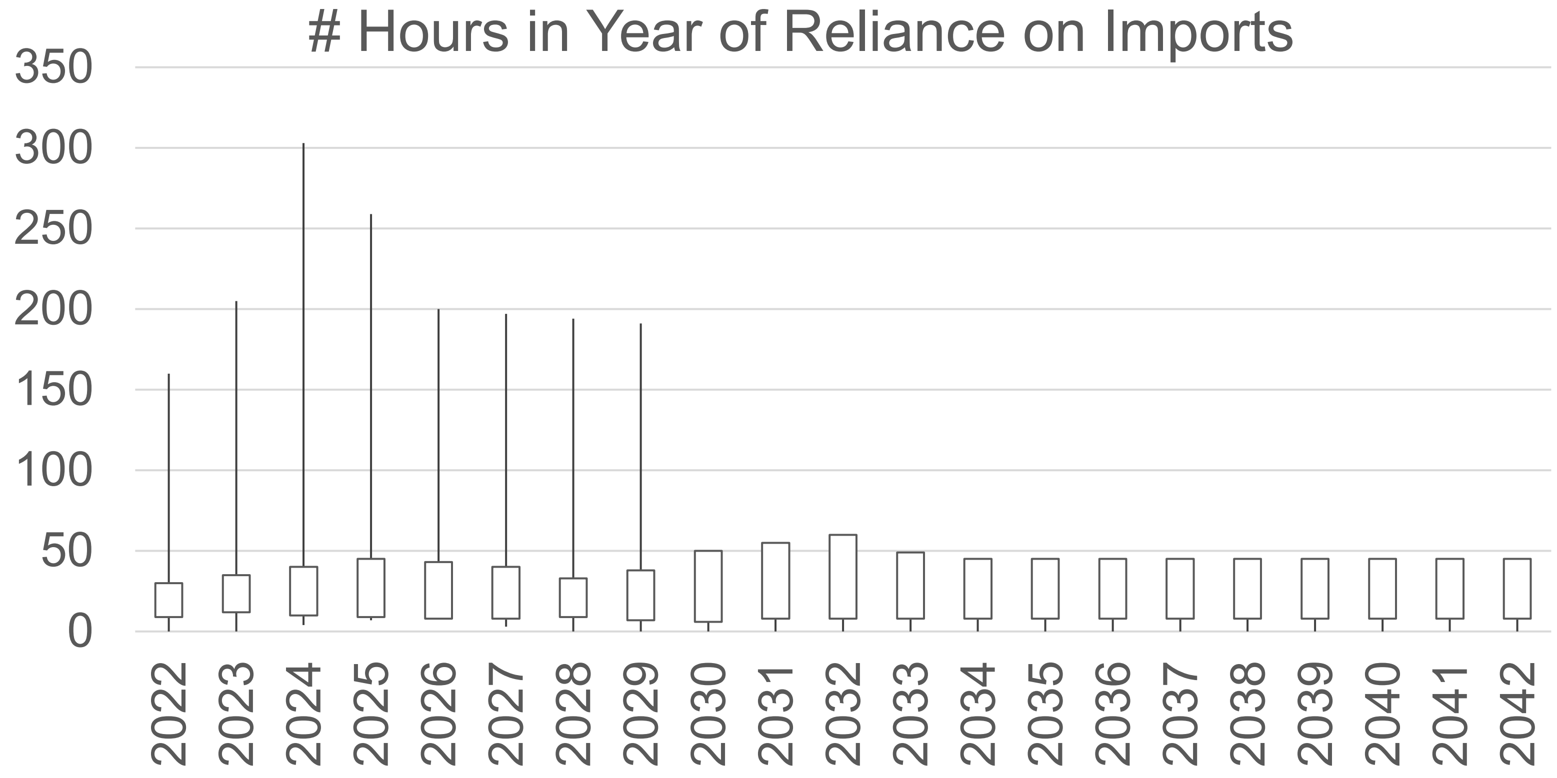
# Import Hrs																								
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	4	2	0	0
7	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	15	17	10	6	2
8	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	3	17	17	6	2	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	7	3	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0

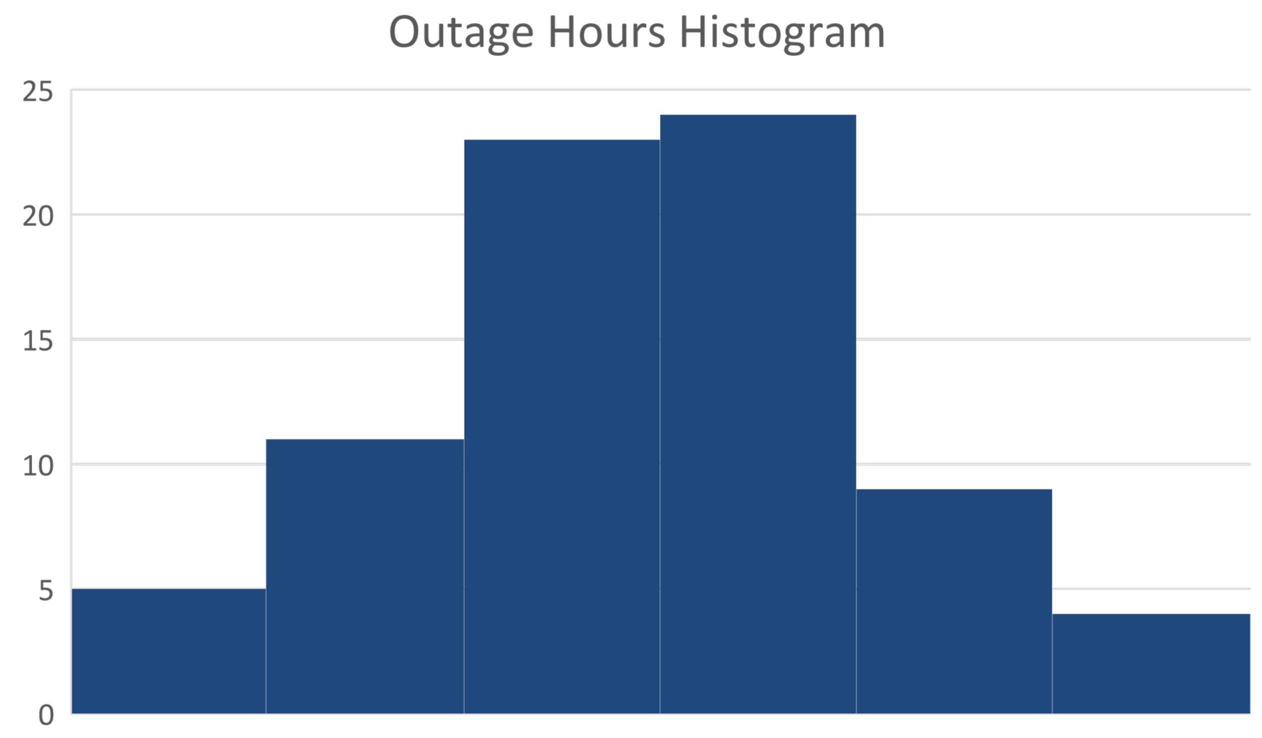
→ The analysis shows that a sample Portfolio P1 is energy long and relies on energy purchases only 136 hours in a year (i.e., 2% of time) to meet its energy needs with a maximum purchase of 475MW, while it has excess energy to potentially sell 6,658 hours in a year (i.e., 76% of time).

(1) Energy Adequacy – Scenario & Stochastic Study Approaches

Illustrative sample analyses, not related to AES-Indiana system or portfolios







(3) Importance and Impacts of Short Circuit Strength

Illustrative sample analyses, not related to AES-Indiana system or portfolios

Importance:

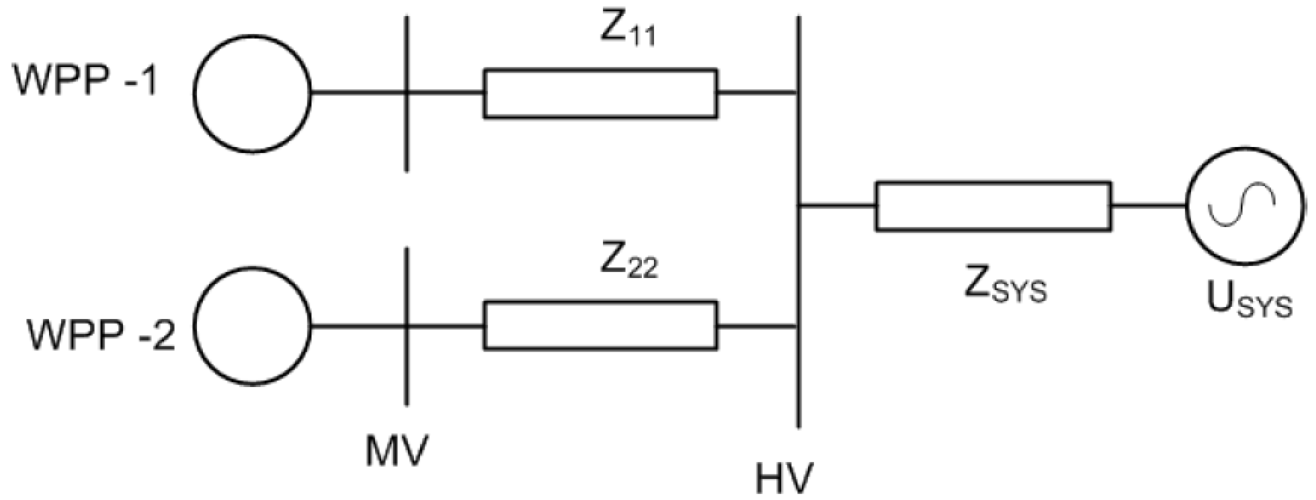
- Short Circuit MVA (SCMVA) is a measure of the strength of a bus in a system. The larger SCMVA, the stronger the bus. That indicates the bus is close to large voltage sources, and thus it will take large injections of real or reactive power to change its voltage. SCMVA changes depending on grid configuration and on-line resources. The lowest SCMVA is usually utilized for engineering calculations.
- When IBRs are interconnected to a system, it is desirable to maintain a stable bus voltage irrespective of the fluctuation of the IBR's output. Similarly, grid following (GFL) inverters rely on stable voltage and frequency to synchronize to the grid using their phase locked loops (PLL).
- The maximum allowable size of IBR desiring to interconnect to a bus is limited to a fraction of the bus's short circuit MVA, say less than 20-50%. This is expressed as Short Circuit Ratio (SCR) of the ratio of SCMVA to the rating of the IBR. This will translate to SCR of 2-5.
- When multiple IBRs are interconnected at a close electrical distance, their controls interact, and the impact of system voltages will increase. Thus, a modified measure was adopted to be ESCR (Effective SCR) to capture this interaction.

Impact:

- When conventional power plants with synchronous generators are retired and/or the system tie-lines are severed, the short circuit currents will dramatically decline. IBRs are not a substitute because their short circuit contribution is limited, and also the phase of their current (real) is not aligned with typical short circuit currents (reactive).
- Declining SCMVA and increasing IBRs will eventually violate the ESCR limits, requiring either a prohibition on additional IBR interconnections, or provisioning additional mitigation measures.
- Mitigations can come in the form of optimal placement of IBRs to avoid clustering them in a manner that violates the ESCR limits, provisioning synchronous condensers, or requiring inverters to have grid-forming (GFM) capability.

(3) Short Circuit Strength: Equivalent Short Circuit Ratio

Illustrative sample analyses, not related to AES-Indiana system or portfolios



Bus #	IBR* (MW)	SCMVA	SCR	ESCR	ESCR with SC
237	30	343	11.5	2.1	3.2
59200	32	369	11.5	2.3	3.7
59100	32	600	18.7	2.5	4.0
238	23	206	8.9	2.2	4.2
1813	10	605	60.0	2.6	4.2
99000	20	481	24.0	2.6	4.2
119	29	311	10.8	3.0	4.2
56	29	343	12.0	2.2	4.3
94	28	1092	39.0	2.7	4.6
59400	23	736	32.0	3.1	4.8
2803	28	548	19.8	3.0	4.9

SCR is not a good indicator under high IBR penetration
Synchronous Condensers (SC) can increase short circuit strength

$$ESCR_i = \frac{S_i}{P_i + \sum_j IF_{ji} * P_j}$$

where $IF_{ji} = \frac{\Delta V_j}{\Delta V_i}$ is the interaction factor between buses i and j and can be calculated using Zbus.

Pi and Pj are the inverter ratings at buses i and j respectively, while Si is the minimum short circuit MVA at bus i.

Optimal Placement of IBRs* from Short Circuit perspective to avoid ESCR limitation:

$$MAXIMIZE \ \sum_{j \in buses} P_j$$

Subject to $\sum_j IF_{ji} * P_j \le \frac{S_i}{ESCR\ Threshold}$

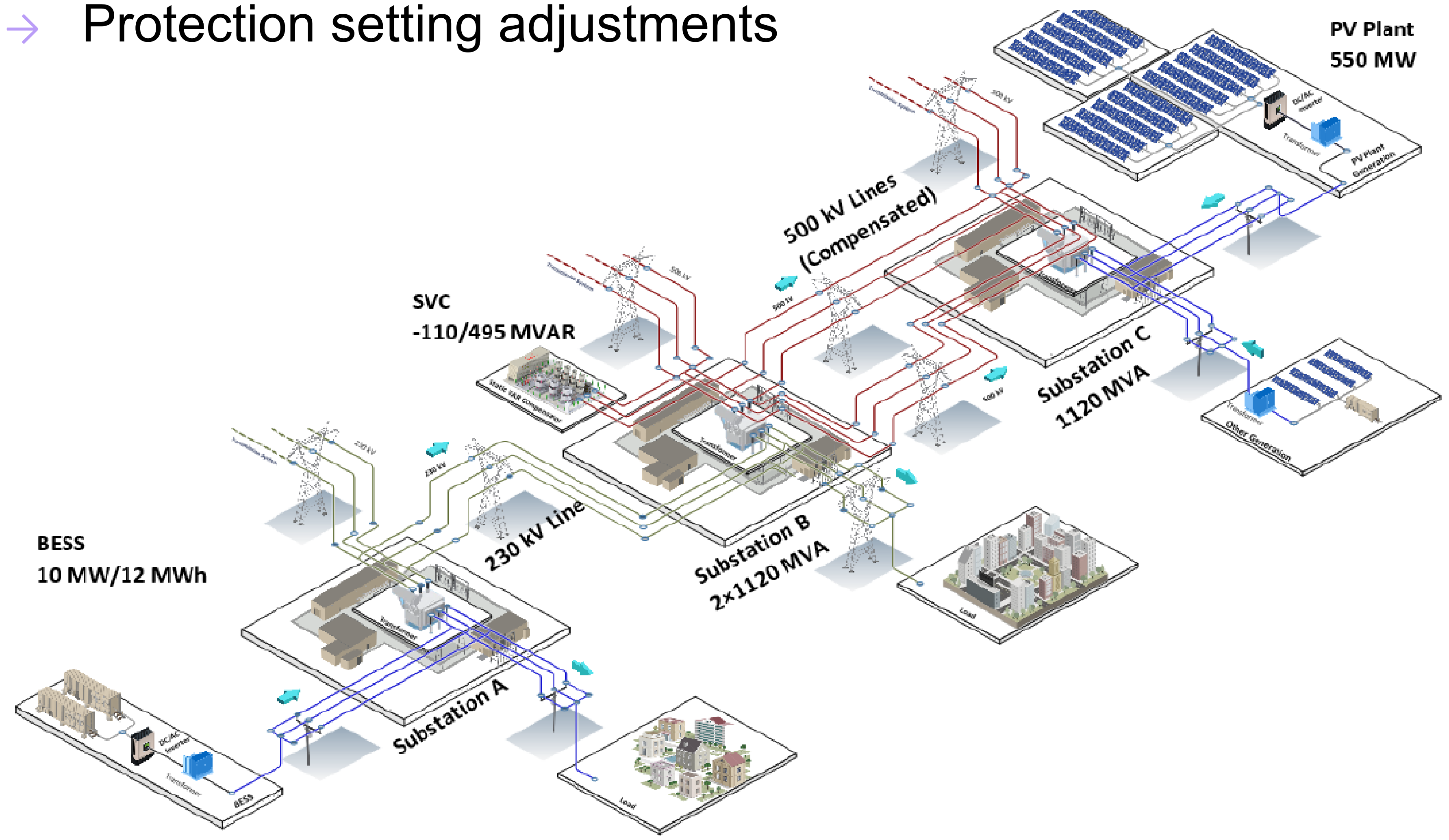
$$P_j \ge 0$$

*Inverter Based Resource (IBR)

(5) Black Start Studies – Key Considerations

Illustrative sample analyses, not related to AES-Indiana system or portfolios

- **Modeling:**
  - Sequencing of Essential Motors (Startup and Shutdown)
  - Modeling of Induction Motors (dynamic characteristics)
  - Protection system Modeling
  - Fast bus transfer
  - Battery System
  - Transformers
- **Analysis:**
  - Transient and steady-state simulations
- **Considerations:**
  - Inverter short-circuit current limitations
  - Soft-start techniques
  - Dynamic interactions
  - Frequency and Voltage control
  - Protective relay operation in view of limited short circuit currents
- **Results:**
  - Inverter Size (MVA, PF)
  - BESS Size (MW, MWh)
  - BESS control and protection settings
  - Transformer tap settings
  - Protection setting adjustments

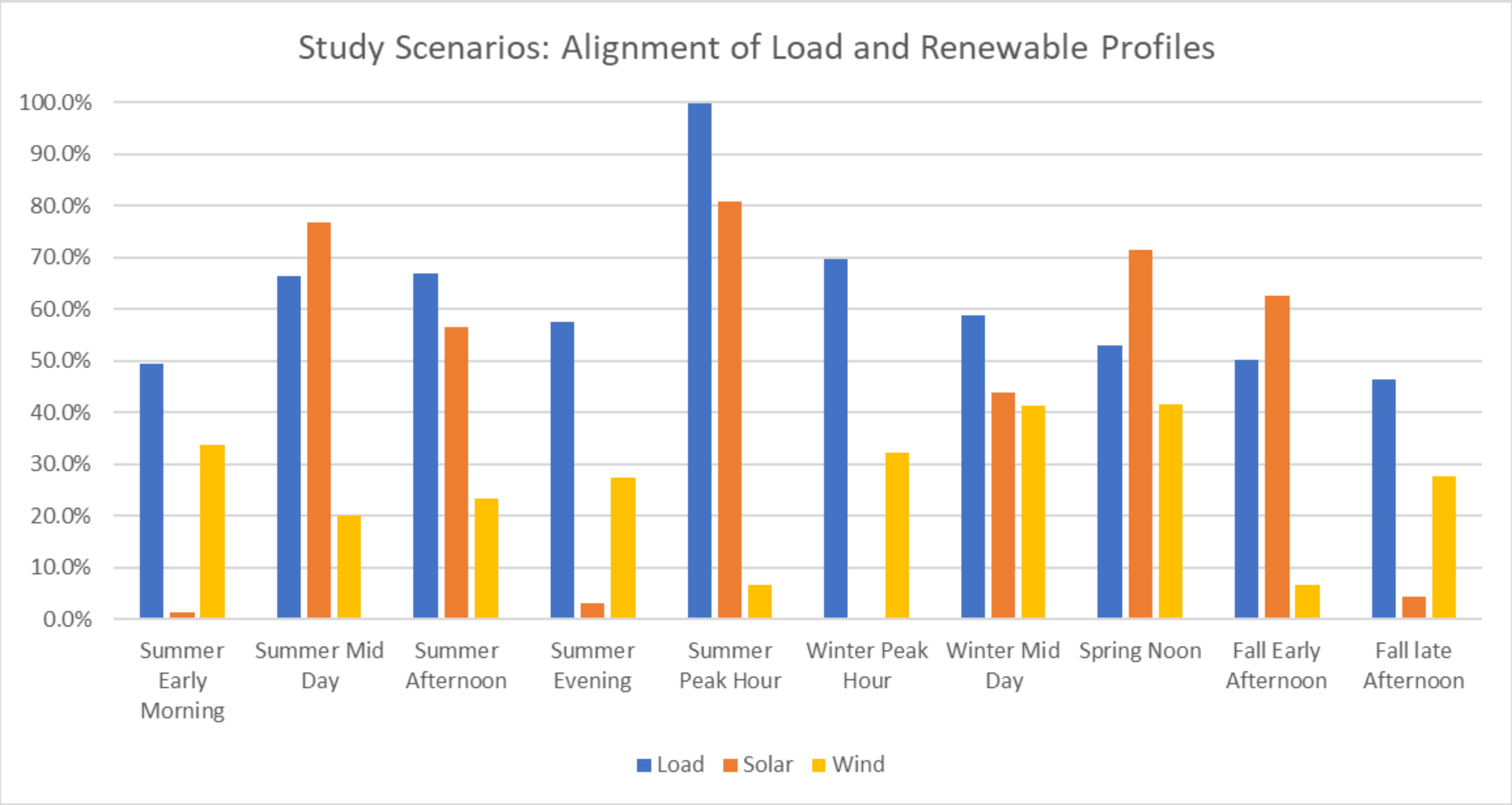


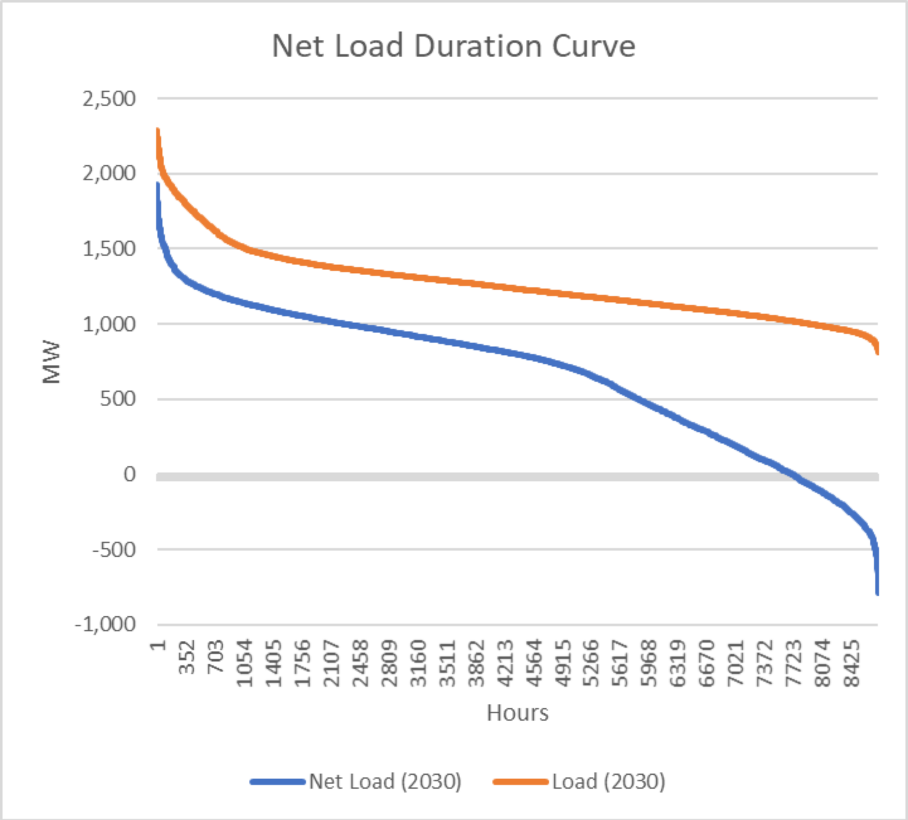
(8) Resource Predictability & Firmness: Variability Analysis

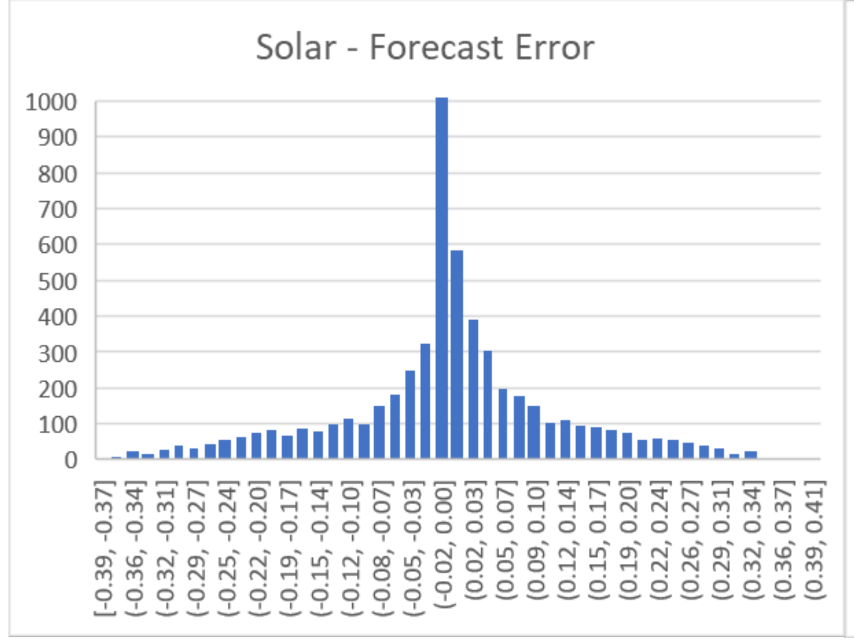
Illustrative sample analyses, not related to AES-Indiana system or portfolios

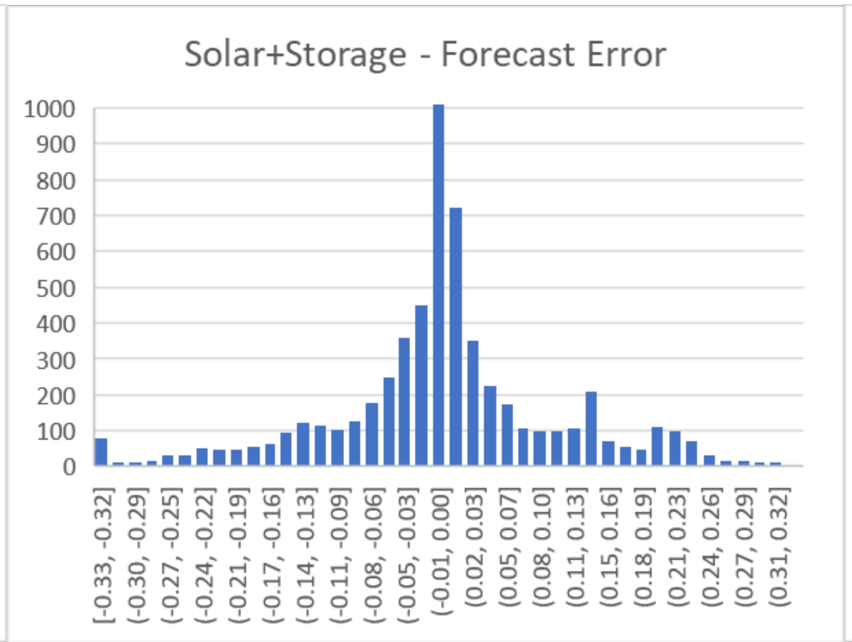
- The hourly profiles of Solar, Wind, and Solar plus Storage are characterized across two dimensions:
  - Forecast Error
  - Alignment with Load
- This characterization is utilized in subsequent evaluation of portfolios of these resources.

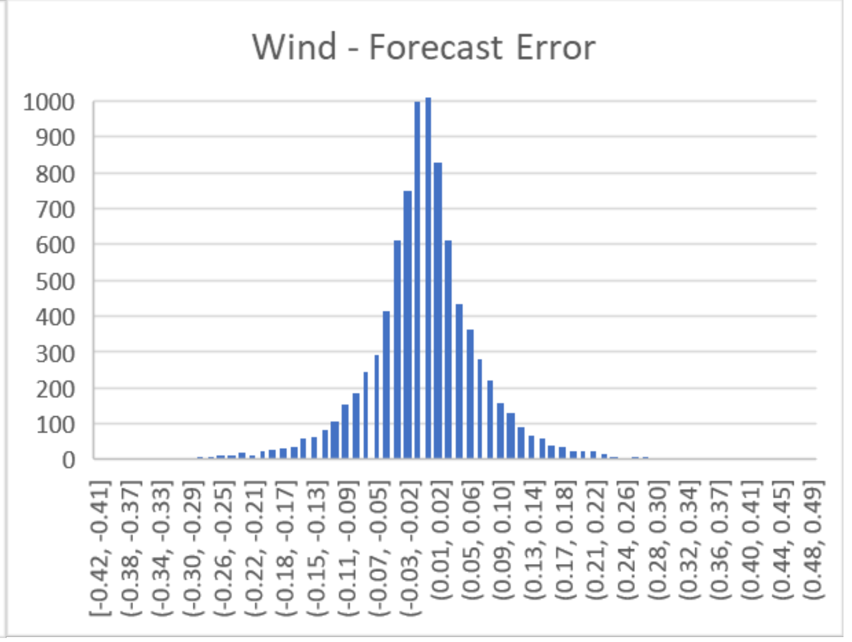
Forecast Error%	Solar	Wind	S+S
Standard Deviation	9.9%	7.5%	9.2%
min Error	-39%	-42%	-33%
max Error	39%	48%	33%
90% Percentile	19%	8%	12%











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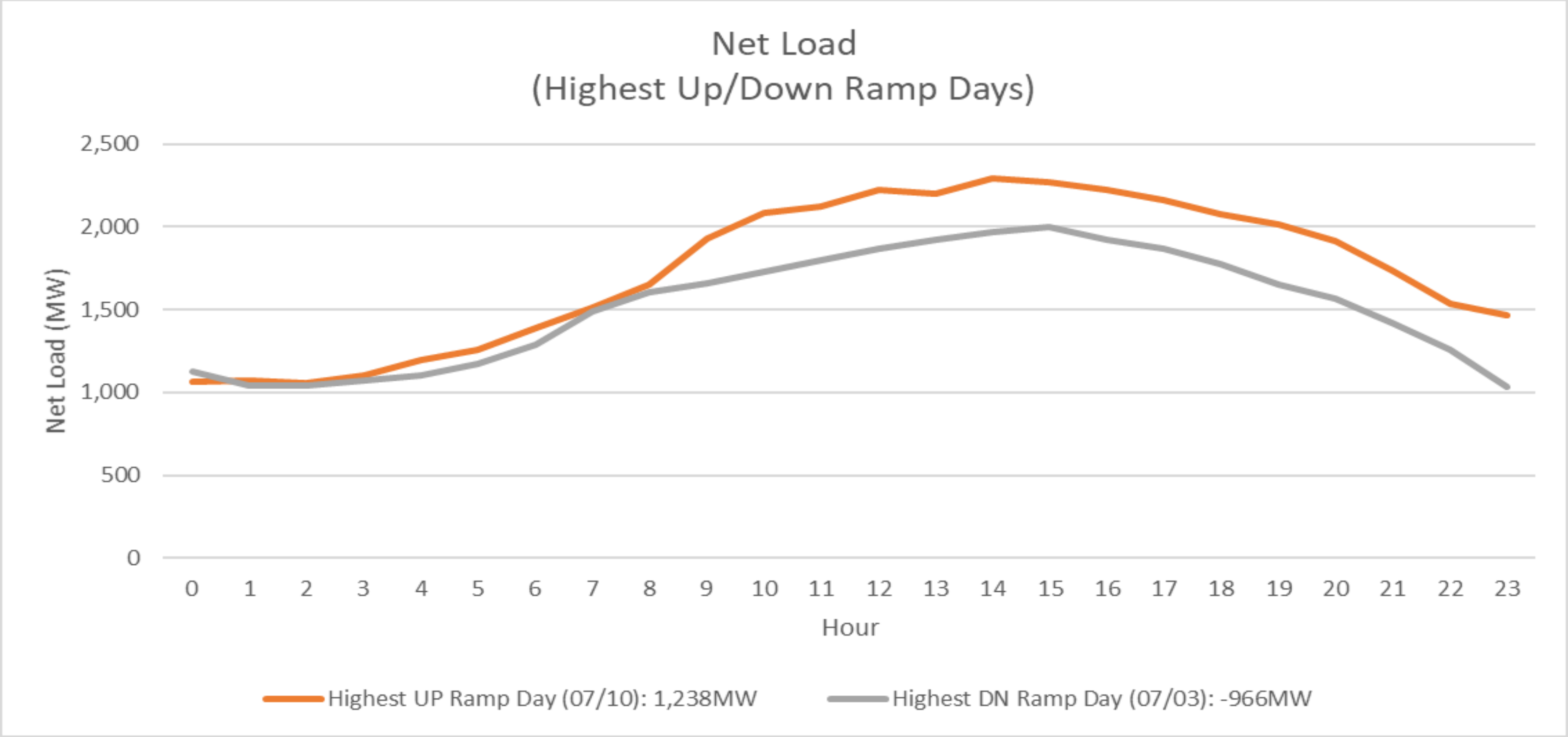
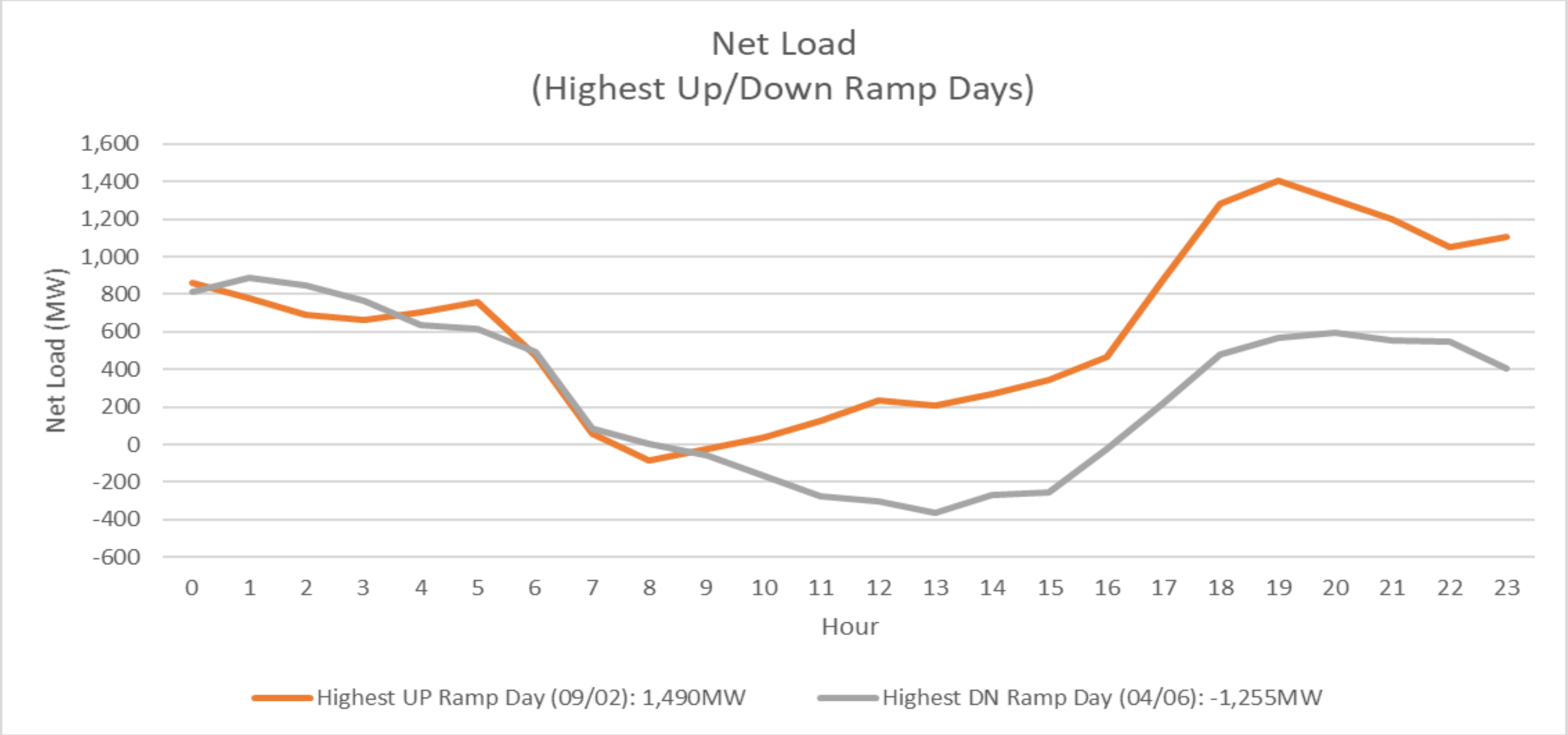
(8) Resource Predictability & Firmness: Net Load Power Ramps

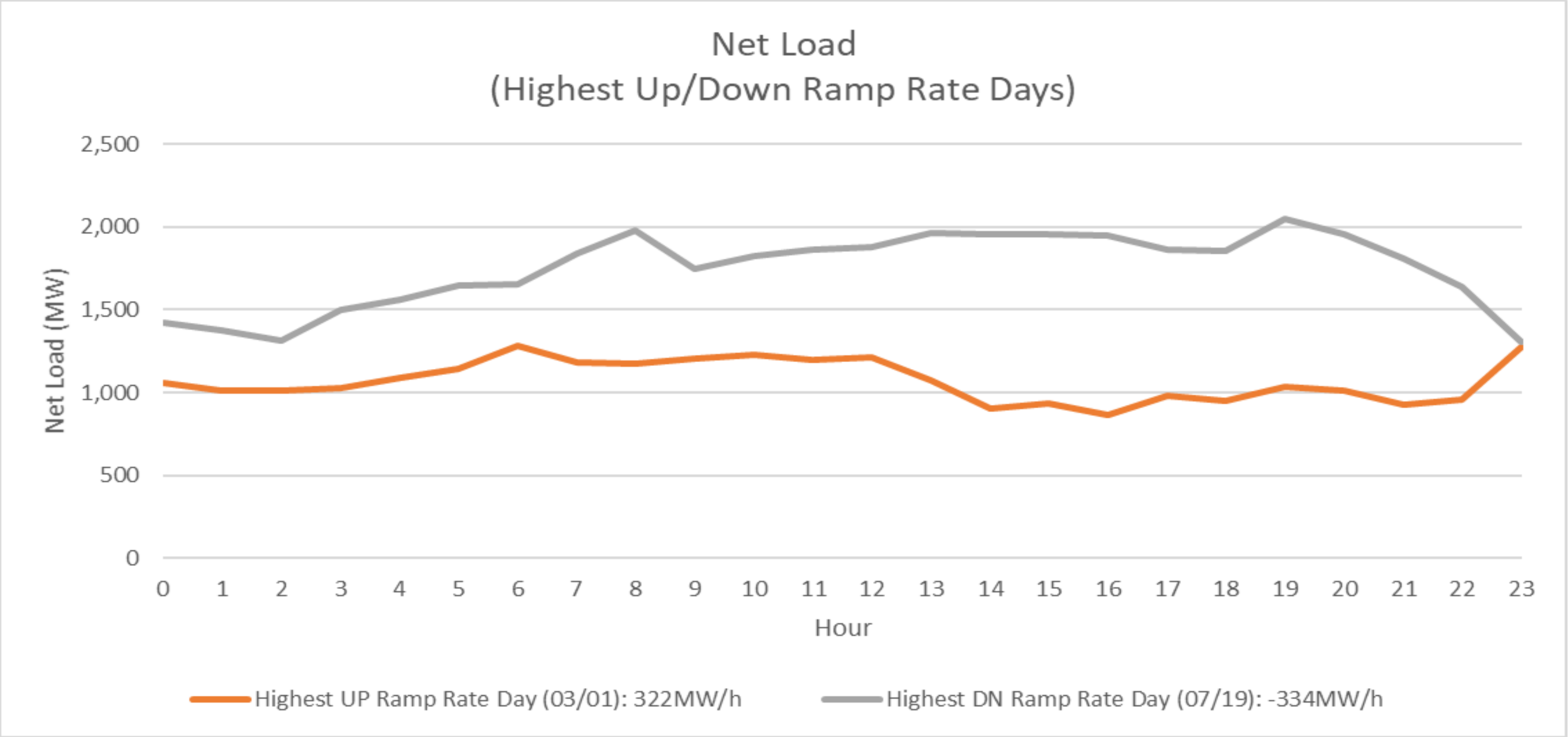
Illustrative sample analyses, not related to AES-Indiana system or portfolios

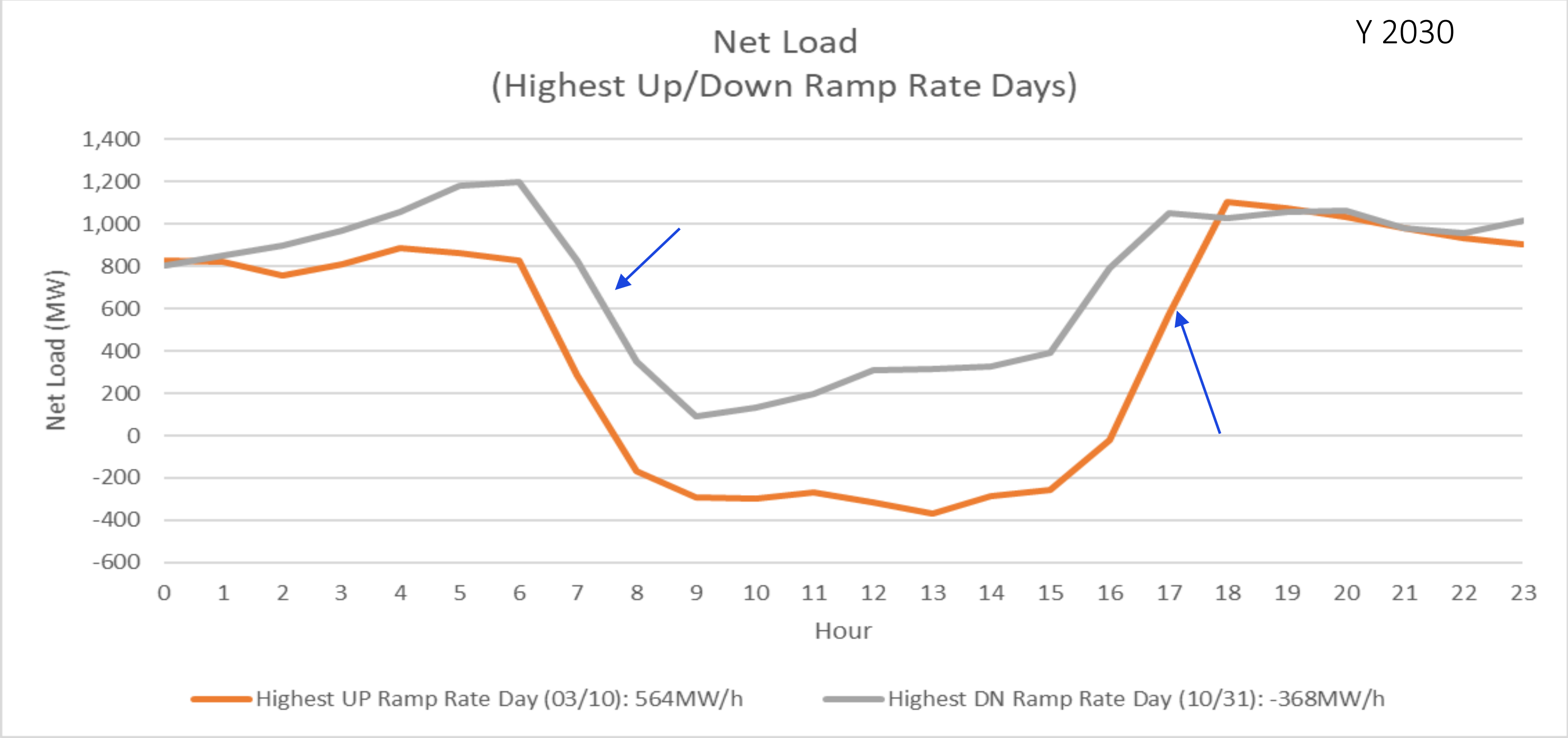
- Highest Up/Down Ramp Days





- Highest Up/Down Ramp Rate Hours





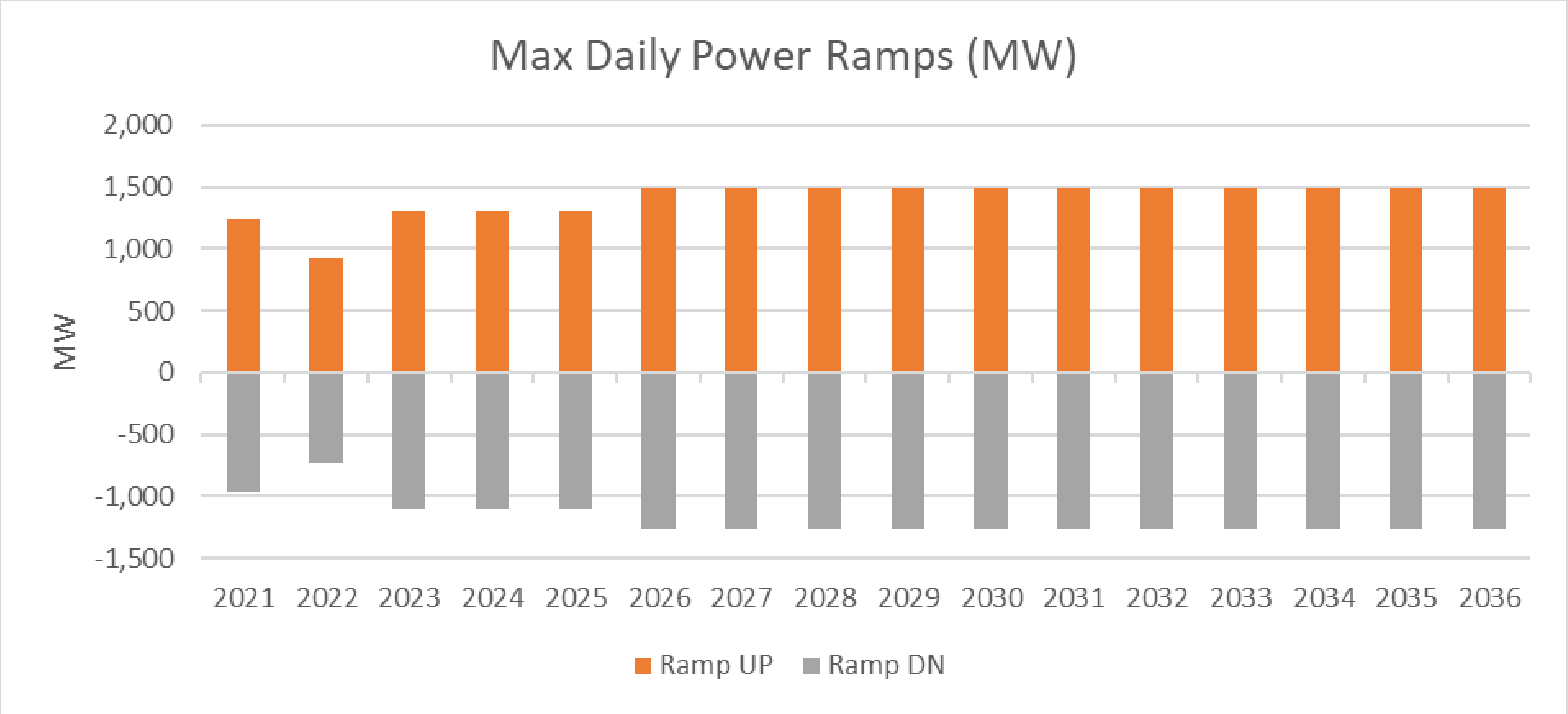
- Significant change in Net Load profile from a conventional shape in 2020 to a "Duck Curve" in 2030

(8) Resource Predictability & Firmness: Net Load Power Ramps

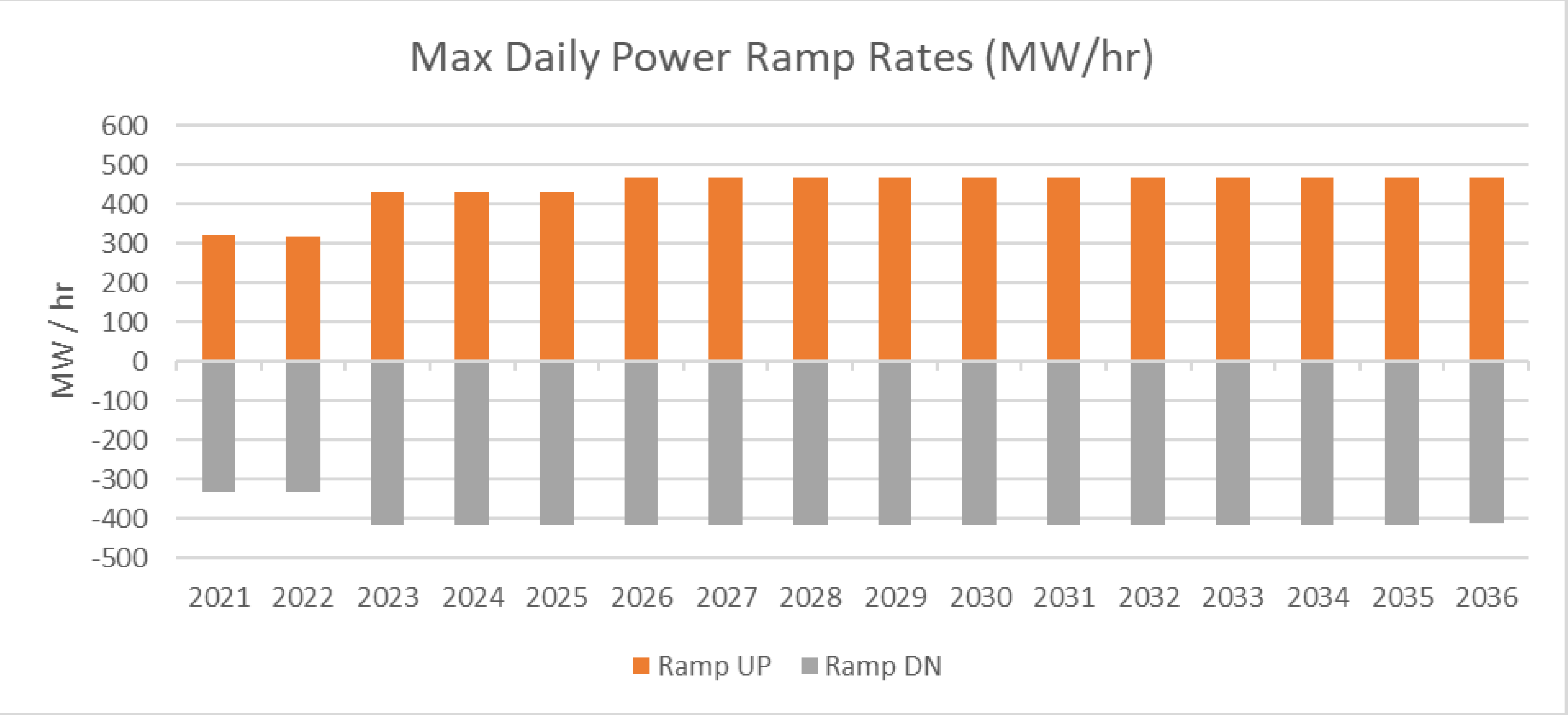
Illustrative sample analyses, not related to AES-Indiana system or portfolios

→ Portfolio P3 (without Storage/Peakers Dispatch)

Year	Ramp UP	Ramp DN	Ramp Rate UP	Ramp Rate DN
2021	1,238	-966	322	-334
2022	929	-733	319	-332
2023	1,309	-1,101	431	-415
2024	1,308	-1,101	430	-414
2025	1,307	-1,101	430	-414
2026	1,490	-1,255	468	-414
2027	1,490	-1,255	468	-414
2028	1,490	-1,255	468	-414
2029	1,490	-1,255	468	-414
2030	1,490	-1,255	468	-413
2031	1,489	-1,255	467	-413
2032	1,489	-1,255	467	-413
2033	1,489	-1,255	467	-413
2034	1,489	-1,255	467	-413
2035	1,489	-1,255	467	-413
2036	1,489	-1,255	467	-413



Ramping Category	2020 MW	2020 %Peak	2030 MW	2030 %Peak	Increased MW 2030 vs. 2020
1-hr Up	306	13.1%	468	20.5%	162
1-hr Down	-222	9.5%	-413	18.1%	191
Day Up	1,044	44.6%	1,489	65.2%	445
Day Down	-852	36.4%	-1,255	54.9%	403



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(8) Resource Predictability & Firmness: Net Load Power Ramps (Y2030 vs Y2020)

Illustrative sample analyses, not related to AES-Indiana system or portfolios

Portfolio	Solar	BTM Solar	Wind	Solar + Storage	Day Ramping Up (MW)	Day Ramping Down (MW)	1hr Ramping Up (MW)	1hr Ramping Down (MW)	Peaker/ Storage (MW)	Forecast Error 90th Percentile	Excess Ramping Capability (MW)
2020	**22**	**270**	**103**	**87**	**1,013**	**-860**	**243**	**-299**	**465**	**89**	**375**
P1	1,225	359	103	224	1,851	-1,557	506	-446	605	342	262
P2	1,725	359	103	224	1,988	-1,557	591	-455	605	434	171
P3	2,225	359	103	224	1,988	-1,557	676	-682	605	526	79
P4	2,725	359	103	224	2,258	-1,827	801	-817	1,225	618	607
P5	3,225	359	103	224	2,258	-1,827	872	-817	1,225	710	515
P6	3,975	359	103	224	2,258	-1,827	936	-817	1,225	848	377
P7	4,225	359	103	224	2,438	-2,007	1,026	-907	2,365	894	1,471
P8	4,225	359	103	224	2,438	-2,007	1,026	-907	2,365	894	1,471
P9	4,225	359	103	224	2,438	-2,007	1,026	-907	2,365	894	1,471

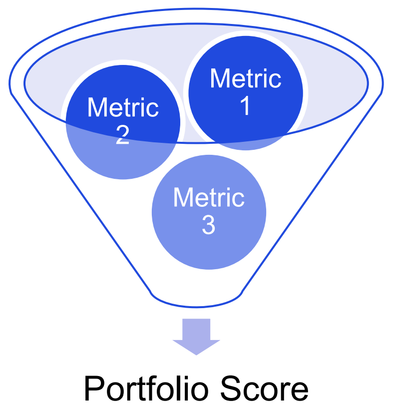
- Balancing areas are required per BAL-003 to comply with CPS1 and CPS2. CPS2 is a monthly standard intended to limit unscheduled flows. It requires compliance better than 90% that the average ACE will remain below a threshold over all 10-min intervals in the month. For a balancing area with a peak load of 2945 MW, the threshold is around 89MW.
- A small percentage (≈20%) of the hourly ramps in Net Load can be forecasted an hour ahead using a persistent forecast method and thus can scheduled in the real time market or accounted for in the dispatch algorithm,. Example, Portfolio P5 has total 1-hour ramp up of 872 MW while its forecast error is 710 MW, or 81%.
- The unforecasted changes in renewable resource outputs should be mitigated using fast ramping resources.
- Portfolios will be ranked according to their ability to mitigate unscheduled flow.

Summary – Next Steps

	Reliability Study Area	Normal (50/50, Connected)	Max-Gen (90/10, Import Limited)	Islanded (Critical Load)
1	Energy Adequacy		X	X
2	Operational Flexibility and Frequency Support	X		X
3	Short Circuit Strength Requirement	X		X
4	Power Quality (Flicker)	X		
5	Blackstart			X
6	Dynamic VAR Deliverability	X		
7	Dispatchability and Automatic Generation Control	X		
8	Predictability and Firmness of Supply	X		
9	Geographic Location Relative to Load	X		

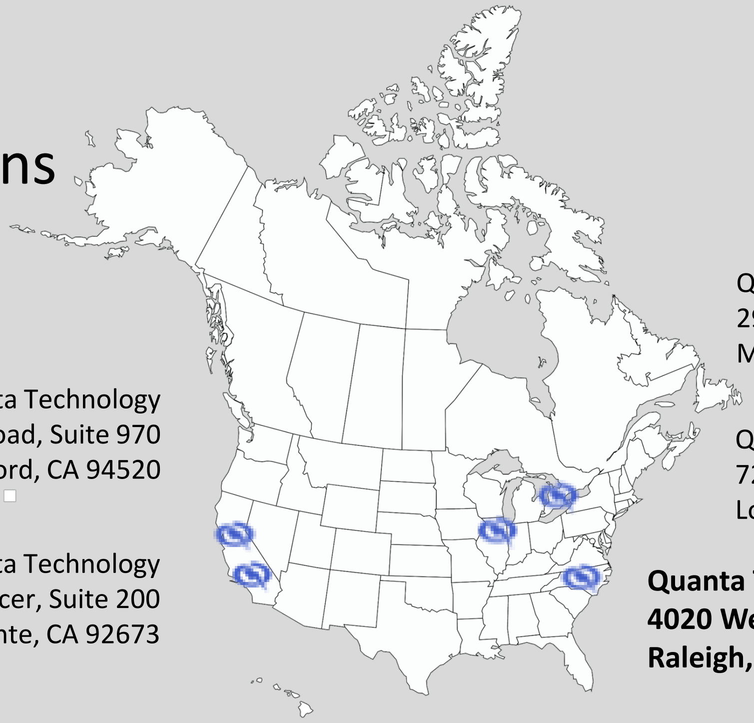
Scoring Criteria

Evaluate Portfolios



Thank you

Office Locations



Quanta Technology
2300 Clayton Road, Suite 970
Concord, CA 94520

Quanta Technology
905 Calle Amanecer, Suite 200
San Clemente, CA 92673

Quanta Technology Canada, Ltd.
2900 John Street, Unit 3
Markham, Ontario, L3R 5G3

Quanta Technology
720 East Butterfield Rd., Suite 200
Lombard, IL 60148

Quanta Technology, LLC (HQ)
4020 Westchase Blvd., Suite 300
Raleigh, NC 27607

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QUANTA TECHNOLOGY aes Indiana

Portfolio Metrics & Scorecard

Erik Miller, Manager, Resource Planning, AES Indiana

Guidance for the IRP Scorecard Framework

21st Century Policy Development Task Force – IURC/SUFG/LBNL/Indiana University – Ongoing

House Enrolled Act 1278 (2019) directed the Indiana Utility Regulatory Commission (IURC) to conduct a comprehensive study of the statewide impacts, both near and long term, of

- **(1)** Transitions in the fuel sources and other resources used to generate electricity by electric utilities; and
- **(2)** New and emerging technologies for the generation of electricity, including the potential impact of such technologies on local grids or distribution infrastructure; on electric generation capacity, system reliability, system resilience, and the cost of electric service for consumers. In conducting the study required, the Commission shall consider the likely timelines for the transitions in fuel sources and other resources described in subdivision (1) and for the implementation of new and emerging technologies described in subdivision (2).

http://iga.in.gov/legislative/2020/committees/21st_century_energy_policy_development_task_force

Categorical Framework for AES Indiana's IRP Scorecard

21st Century Energy Policy Development Task Force Framework #1: The Five Attributes or "Pillars" of Electric Utility Service

1) Reliability
2) Resilience
3) Stability
4) Affordability
5) Environmental Sustainability

Additional Scorecard Categories

6) Risks & Opportunities
7) Social & Economic Impact

Each category has one or more metrics that quantitively measure portfolio performance.

IRP Scorecard for Portfolio Evaluation

→ **The Current Trends (Reference Case) will be evaluated using the Scorecard below:**

	Affordability	Environmental Sustainability				Reliability, Stability & Resiliency	Risk & Opportunity						Economic Impact	
	20-yr PVRR	***CO_2 Emissions***	***SO_2 Emissions***	***NO_x Emissions***	***Other Emissions***	***Reliability Score***	***Environmental Policy Opportunity***	***Environmental Policy Risk***	***Cost Opportunity***	***Cost Risk***	***Market Exposure***	***Renewable Capital Cost Risk***	***Employees (+/-)***	***Property Taxes***
	Present Value of Revenue Requirements	Total portfolio CO2 Emissions	Total portfolio SO2 Emissions	Total portfolio NOx Emissions	Water Use & Coal Ash	Composite score from Reliability Analysis	Lowest PVRR across policy scenarios	Highest PVRR across policy scenarios	Mean - P5	P95 - Mean	20-year avg sales + purchases	**TBD**	Total # of AES IN generation employees	Total amount of property tax paid from AES IN assets
1)														
2)														
3)														
4)														
5)														
6)														

Calculations for each scoring metric will be included to complete the Scorecard

→ **Strategies**

- 1. No Early Retirement
- 2. Pete Refuel to 100% Natural Gas (est. 2025)
- 3. One Pete Unit Retires in 2026
- 4. Both Pete Units Retire in 2026 & 2028
- 5. “Clean Energy Strategy” – Both Pete Units Retire and replaced with Renewables in 2026 & 2028
- 6. Encompass Optimization without Predefined Strategy

A Preferred Resource Portfolio will be selected after evaluation of the Scorecard results

Affordability Metric

- **20-year Present Value of the Revenue Requirements (PVRR)**
  - Calculation:

PVRR =

Operating Expenses
- Energy Purchases
- Fuel
- Variable O&M
- Fixed O&M
- Emissions

\+

Recovery of and Return on New Capital
- Book Depreciation
- Return on Rate Base
- Property Taxes

−

Market Revenues
- MISO Energy Revenue
- Net Capacity Revenue

Environmental Sustainability Metrics

- **CO2 Emissions**
  - Calculation: Total portfolio short tons of CO_2
- **SO2 Emissions**
  - Calculation: Total portfolio short tons of SO_2
- **NOx Emissions**
  - Calculation: Total portfolio short tons of NO_x
- **Other Emissions & Byproducts – Water Use, Coal Ash**
  - Calculation Example: Portfolio receives a 0 if it includes coal past 2028 and 1 if it does not

Note: Portfolios that score poorly on Environmental Sustainability also present higher cost risk to customers in the form of environmental compliance for pollutants and biproducts.

Reliability, Resilience and Stability Metric

→ **Reliability Metric**

- Calculated through Quanta's Analysis
- Composite score of reliability, resilience and stability metrics that include:
  - Energy Adequacy
  - Operational Flexibility and Frequency Support
  - Short Circuit Strength Requirement
  - Power Quality (Flicker)
  - Blackstart
  - Dynamic VAR Deliverability
  - Dispatchability and Automatic Generation Control
  - Predictability and Firmness of Supply
  - Geographic Location Relative to Load

Risk & Opportunity Metrics

→ Environmental Policy Sensitivity Analysis

- → AES Indiana will model environmental policy sensitivities on the optimized capacity expansion results from the Current Trends (Reference Case) to understand how the PVRR may change in a very different policy future.
- → The results will help to answer the question – “How would the optimized Reference Case perform in a very different policy future, e.g. Reference Case in a Decarbonized Economy future?”

		Current Trends - Reference Case	No Environmental Action	Aggressive Environmental	Decarbonzied Economy
Generation Strategies	No Early Retirement				
	Pete Refuel to 100% Gas (est. 2025)				
	One Pete Unit Retires (2026)				
	Both Pete Units Retire (2026 & 2028)				
	Both Pete Units Retire and Replaced with Wind, Solar & Storage (2026 & 2028)				
	Encompass Optimization without predefined Strategy				

Run the Optimized Reference Case Portfolios/Generation Mixes through the other Scenarios

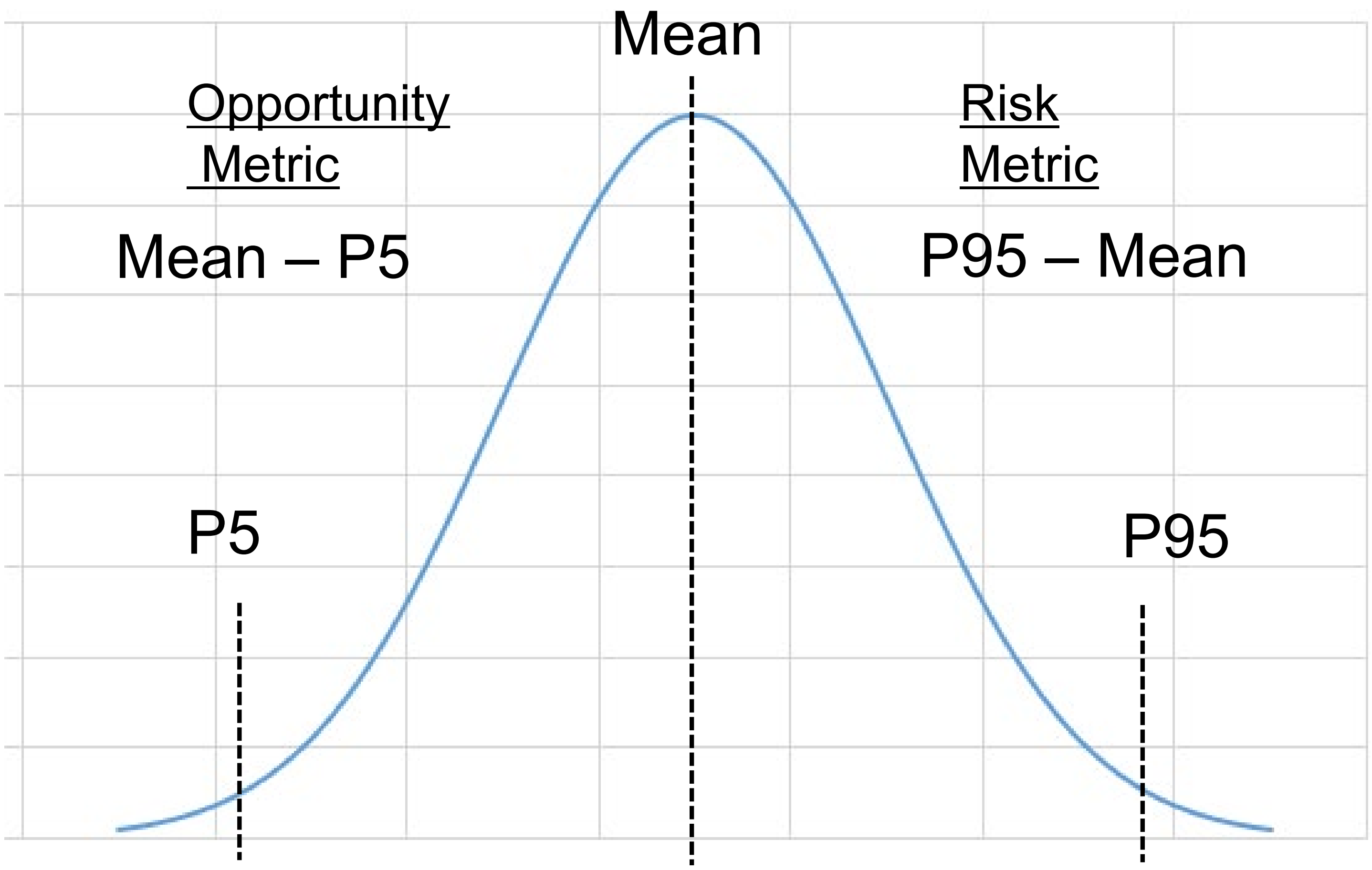
Metrics

For each strategy, the analysis will capture:

- → Risk potential using the **highest scenario PVRR for each strategy**
- → Opportunity potential using the **lowest scenario PVRR for each strategy**

Risk & Opportunity Metrics

- **Cost Risk & Opportunity Metric **Stochastic Analysis****
  - Stochastic analysis will be performed to understand the risks and opportunities to each Strategy from:
    - Gas price volatility
    - Energy price volatility
    - Load volatility
    - Renewable generation volatility
  - Each variable will be varied across a full stochastic distribution using 100 iterations of potential outcomes.
  - Metrics to measure cost risks and cost opportunities will include:
    - Risk Metric = P95 – Mean
    - Opportunity Metric = Mean – P5

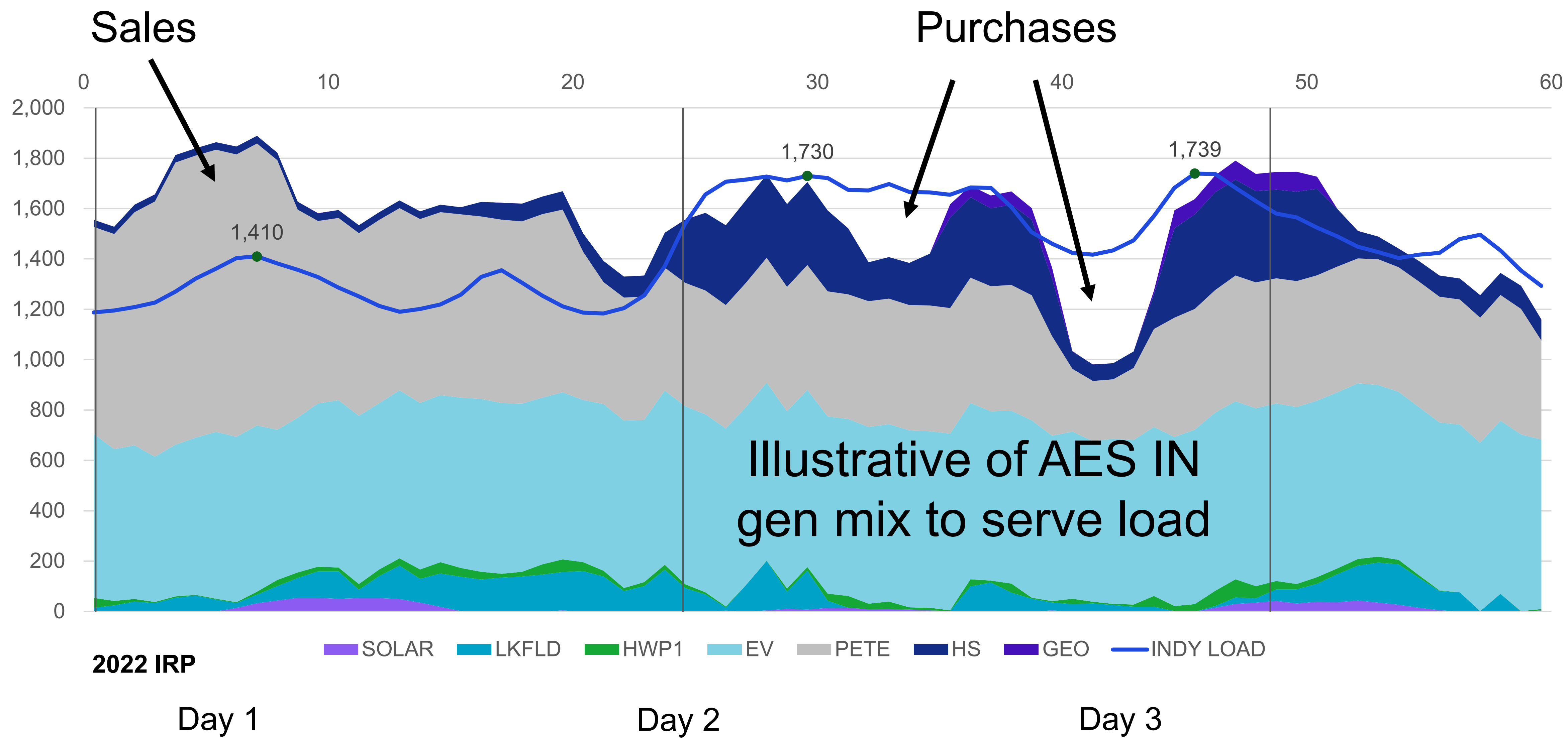


AES Indiana

Risk & Opportunity Metrics

Market Exposure

- When a utility generates energy in excess of load, the energy is sold into the market. Conversely, when a utility is short energy, the utility must purchase energy to supply load.
- Generally, the less sales and purchases in a portfolio, the less risky the portfolio or strategy is for the customer because the sales and purchases aren't exposed to price volatility in the market.
- For example – what if prices drop to zero when wind is available in excess of load or what if prices spike when energy purchases are needed to meet load?



Market Exposure Metric

To estimate the risk for each strategy, AES Indiana will calculate the average of the absolute value of the annual sales and purchases and sum those over the 20-yr period.

$$\left| \text{20-year Average Sales} \right| + \left| \text{20-year Average Purchases} \right|$$

Economic Impact Metrics

- **Number of AES Indiana Generation Employees**
  - Unit retirements and replacement generation mixes across the Generation Strategies will look very different. For example, the IRP analysis will compare a strategy that leaves Petersburg in operation through the entire period to a strategy that retires and replaces Petersburg with all renewables in the near-term.
  - These different strategies will have very different impacts on AES Indiana employees.
  - To compare this impact, AES Indiana will include a metric that estimates the total number of AES Indiana generation employees for each strategy.

- **Total amount of property taxes paid for AES Indiana Generation Assets**
  - Similarly, unit retirements and replacement generation mixes across the Generation Strategies will also have very different impacts on local property taxes.
  - To compare this impact, AES Indiana will include a metric that estimates the total property taxes paid for each generation strategy.

IRP Scorecard for Portfolio Evaluation

→ **The Current Trends (Reference Case) will be evaluated using the Scorecard below:**

	Affordability	Environmental Sustainability				Reliability, Stability & Resiliency	Risk & Opportunity						Economic Impact	
	20-yr PVRR	***CO_2 Emissions***	***SO_2 Emissions***	***NO_X Emissions***	***Other Emissions***	***Reliability Score***	***Environmental Policy Opportunity***	***Environmental Policy Risk***	***Cost Opportunity***	***Cost Risk***	***Market Exposure***	***Renewable Capital Cost Risk***	***Employees (+/-)***	***Property Taxes***
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Calculations for each scoring metric will be included to complete the Scorecard

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- 1. No Early Retirement
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A Preferred Resource Portfolio will be selected after evaluation of the Scorecard results

AES Indiana Distribution System Planning

Kathy Storm, Vice President, US Smart Grid, AES Indiana
Mike Russ, Senior Manager, T&D Planning & Forecasting, AES Indiana

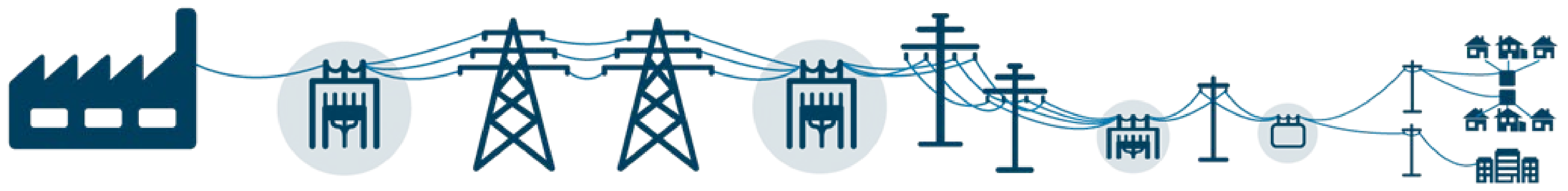
Agenda

- Building the AES Grid of the Future
- Smart Grid Vision
- Integration of Resource & System Planning
- Demand Forecasting & Multi-Scenario Planning
- Distribution Planning Tools
- Distributed Energy Resources (DERs)
- Electric Vehicles
- FERC Order 2222
- Conclusion

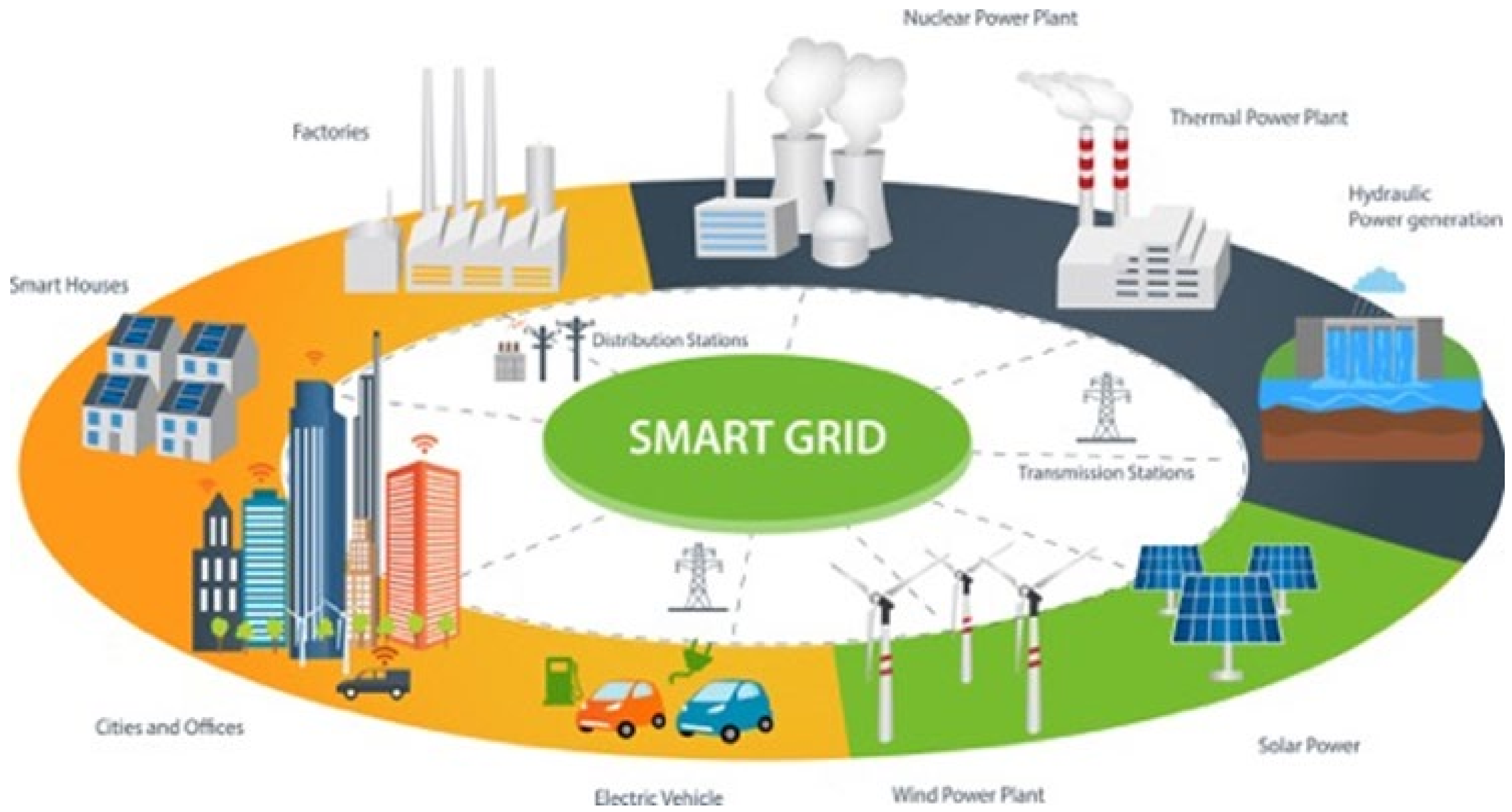
Building the AES of the Future

Transforming the traditional one-way grid into…

An interactive two-way intelligent platform



AES Indiana



Smart Grid Vision

- **AES Smart Grid creates a compelling and competitive advantage in the clean energy market to build value for AES customers, employees, and shareholders.**
- Vision – Customers are the center of everything we do. Together, we drive innovation and new value while delivering a positive customer experience.

CUSTOMER

Engage with our customers through a more personalized experience and build a trusted customer relationship.

SMART GROWTH

Build a distribution system that attracts new customers through innovative clean energy products and services.

INNOVATION

Transform to a customer-focused, data-driven culture that empowers our people to reimaging the energy ecosystem and be leaders in the clean energy transition.

RESILIENCY

Transform our energy system and services to improve resiliency and seamlessly integrate renewables, distributed generation, energy storage and electrification technologies.

Operations Future State Vision

DMS – Distribution Management System
OMS – Outage Management System
DERMS – Distributed Energy Resources Management System
AMI – Advance Metering Infrastructure

Enterprise Integration

- GIS
- CIS
- Work Management
- AMI/MDMS
- Weather Service
- Outage Data Warehouse

DER Dispatch
DER Forecast
DER Monitoring and Control
DER Market Interface
DER Scheduling
DER Estimation

Storm Management
Outage Analysis
Call Management
Planned Outage Management
Outage Reporting
Crew Management

Switch Order Management
Volt/Var Optimization
Distribution Power Flow
Feeder Reconfiguration
Fault Location Restoration
Short Circuit Analysis

Distribution Network Operating Model

Network Model | Topology Processing | Graphical User Interface | DER Modeling | DER Aggregation

Operations Technology Platform

SCADA, Alarming, Trending, Visualization, Historian, Load Shed, Study Mode

Real-Time/DER Communication

Dispatchable Generators | Substation Devices | Feeder Devices | EVs and Charging Stations | Wind | DR and Smart Appliance | Energy Storage | Solar Pv | Microgrids

Mobile Application

- Real Time Map View
- Job Management
- Damage Assessment
- Field Switching
- Off-Line Operation
- GPS Integration

Connected Planning & Operations

Advanced Suite of Planning & Operational Tools

DERs
EVs and Charging Stations
DR and Smart Appliance
Energy Storage

Interconnection Portal

Collect all technical specifications needed for detailed modeling

Demand Forecasting Tool

In alignment with resource planning develop bottom-up geo-referenced forecasts, with forecast updates as a result of resource changes and information from smart grid devices

Network Model Building & Analysis

Develop short, mid, long term power flow study models for T&D systems

Grid Upgrades

Develop solutions for grid interconnection, capacity, and reliability needs

DER Dispatch
DER Forecast
DER Monitoring and Control
DER Market Interface
DER Scheduling
DER Estimation

Storm Management
Outage Analysis
Call Management
Planned Outage Management
Outage Reporting
Crew Management

Switch Order Management
Volt/Var Optimization
Distribution Power Flow
Feeder Reconfiguration
Fault Location Restoration
Short Circuit Analysis

- Collecting all technical data at the front of the interconnection process and translating it directly to standardized forecasting and modeling tools in planning & operations.
- Leveraging Smart Grid investments for better forecasting and model inputs.
- Devices are utilized for better operational visibility & orchestration leading to better customer outcomes.

Smart Grid Devices

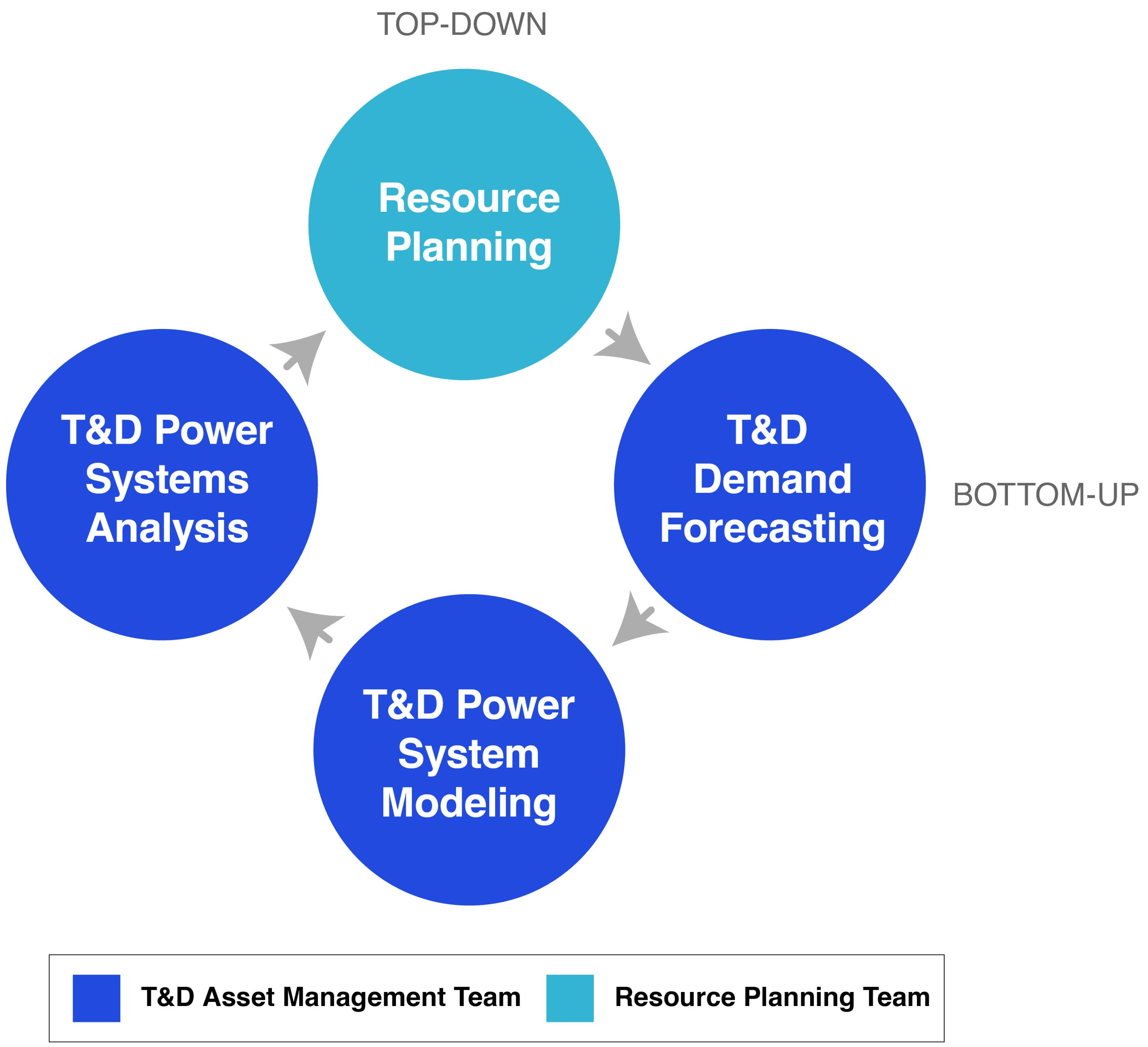
AMI, Smart Reclosers, Sensors, SCADA/Pi, Weather data utilized to build better modes and provide an operations technology platform that enhances planning and operations

AMI – Smart Meters
Substation Devices
Line Reclosers
DR and Smart Appliance

DMS – Distribution Management System
OMS – Outage Management System
DERMS – Distributed Energy Resources Management System
AMI – Advance Metering Infrastructure

Aligned Planning at AES Indiana

- Aligned resource, distribution, transmission, reliability teams and processes for integrated solutions
- AES Indiana has moved to combine the traditional T&D planning roles under one department that works closely with our reliability teams to develop holistic solutions.
  - Processes are mapped such that resource planning and T&D forecasting work off same assumptions for top-down and bottom-up load forecasting.
- T&D system forecasting, modeling, and analysis built off common assumptions
- Focus on building the foundation with an aligned organization, smart grid devices, demand forecasting and network modeling that will enable AES to effectively plan for multiple scenarios and test non-traditional solutions.



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T&D Demand Forecasting Future State Process

Connecting Smart Grid Devices to Future State, Multi-Scenario Planning Models

Smart Grid Device Inputs → **Demand Forecasting** → **System Modeling & Analysis Output**

SAP, OSIsoft | LoadSEER | PSS®E, CYME Power Engineering Software

Asset Data
- → FLOC
- → SCADA/PI
- → AMI
- → DER Data
- → GIS
- → Co-op/Muni Data
- → Block Load

Landis+Gyr, esri

Load Analysis
- → SCADA Scrubber
- → AMI Pipeline
- → Load Normalization
- → Model 30 Weather Years
- → Hourly Load Profiles

Resource Planning
- → Utility Internal Projections as Constraints

(top-down)

Spatial Analysis
- → Geo-referenced
- → Econometrics
- → Demographics
- → Transportation
- → Probability of Load Growth and DER Penetration

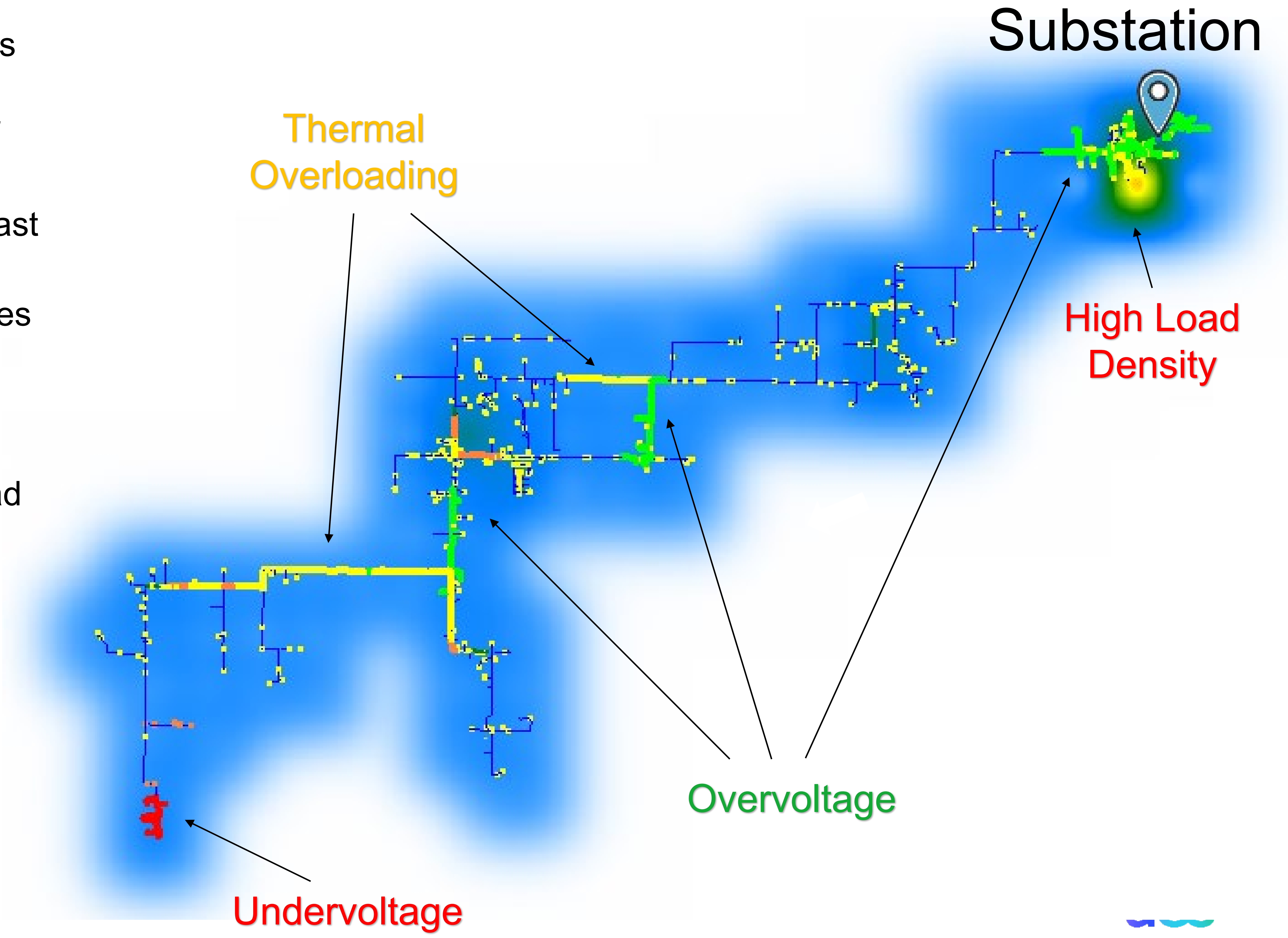
(bottom-up)

Multi-Scenario Development
- → Short, Mid, Long-Term Scenarios
- → Low, Medium, High Growth Rates
- → DER/EV Sensitivities
- → Weather Sensitivities

Power Flow Models
- → CYME
- → PSSE
- → Export to GIS for Visualization
- → Aligned Study Models for T&D in Indiana + Ohio

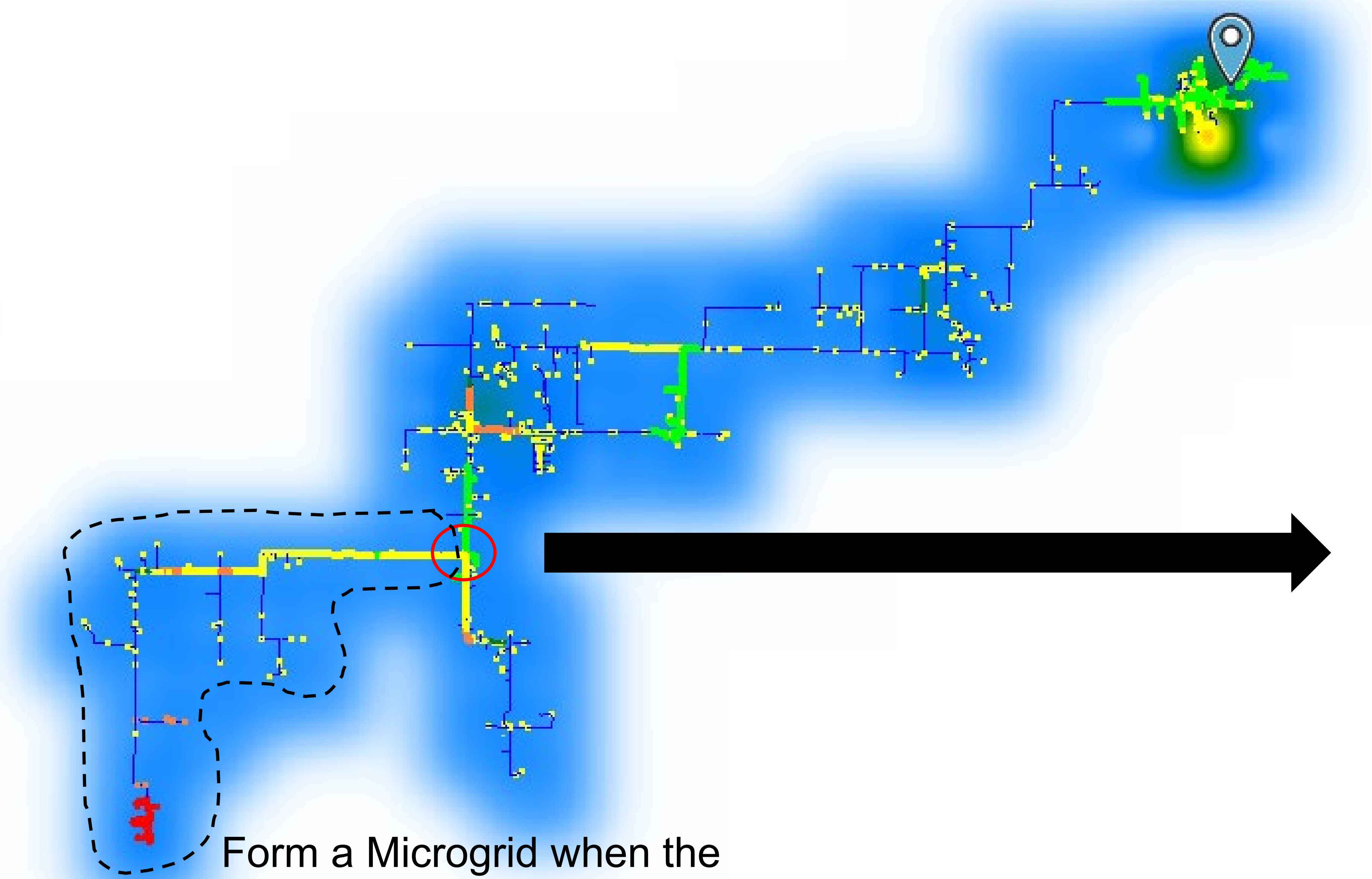
Load Flow Analysis for Distribution Systems

- AES uses CYME for distribution system modeling and analysis
- CYME takes advanced forecasts/scenarios from our demand forecasting tool (LoadSEER) to develop power flow models of the system
  - These forecasts and scenarios will be analyzed to forecast future system capacity, redundancy, and voltage needs
  - Contingency & Scenario Planning present new challenges for distribution since multiple circuit configurations are possible with smart grid devices
- Time series for load profiles
  - Will become more important over time with changing load profiles due to DER, EV charging, etc. being major load modifiers
- Advanced Capabilities Under Development
  - Reliability Assessment
  - Recloser Placement Module
  - Time Series
  - Hosting Capacity

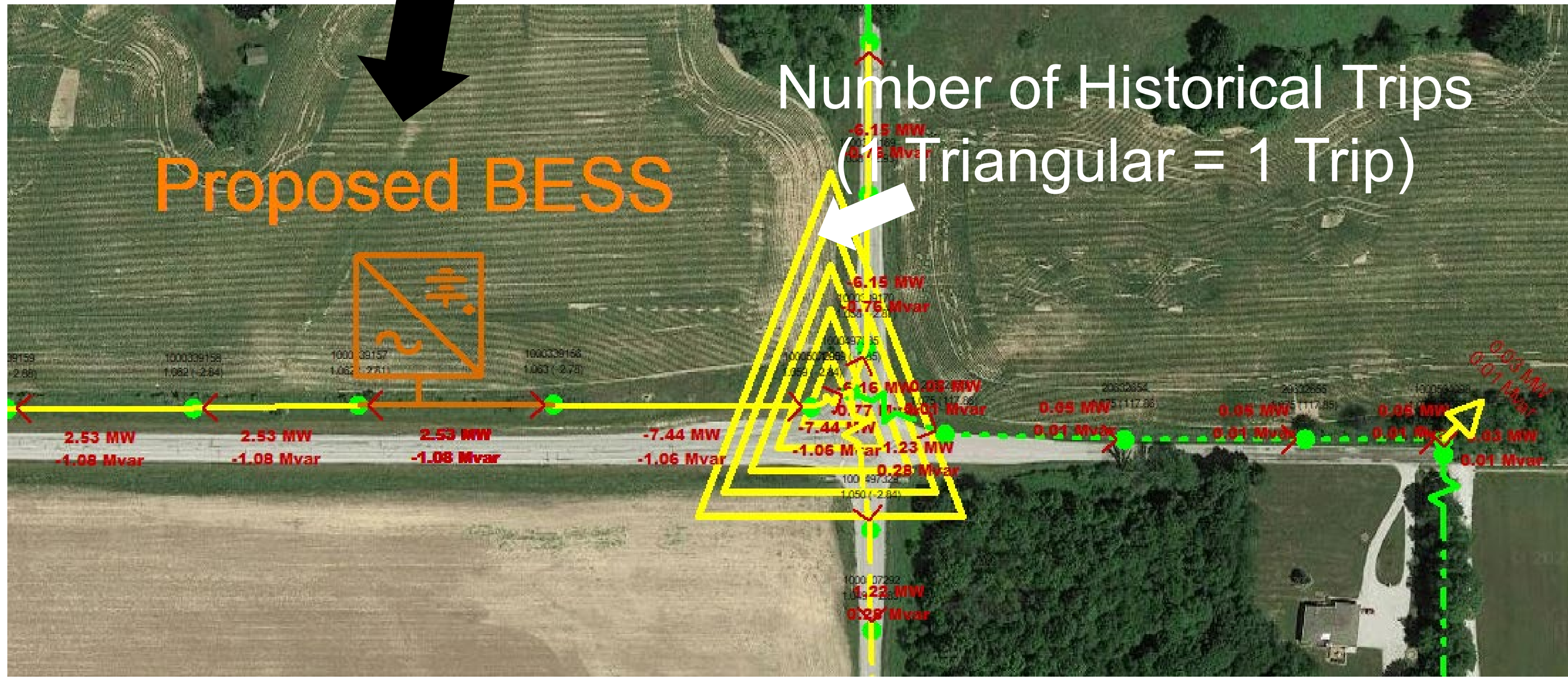


Example of a Battery Energy Storage System (BESS) (a Non-Wire Alternative)

Substation

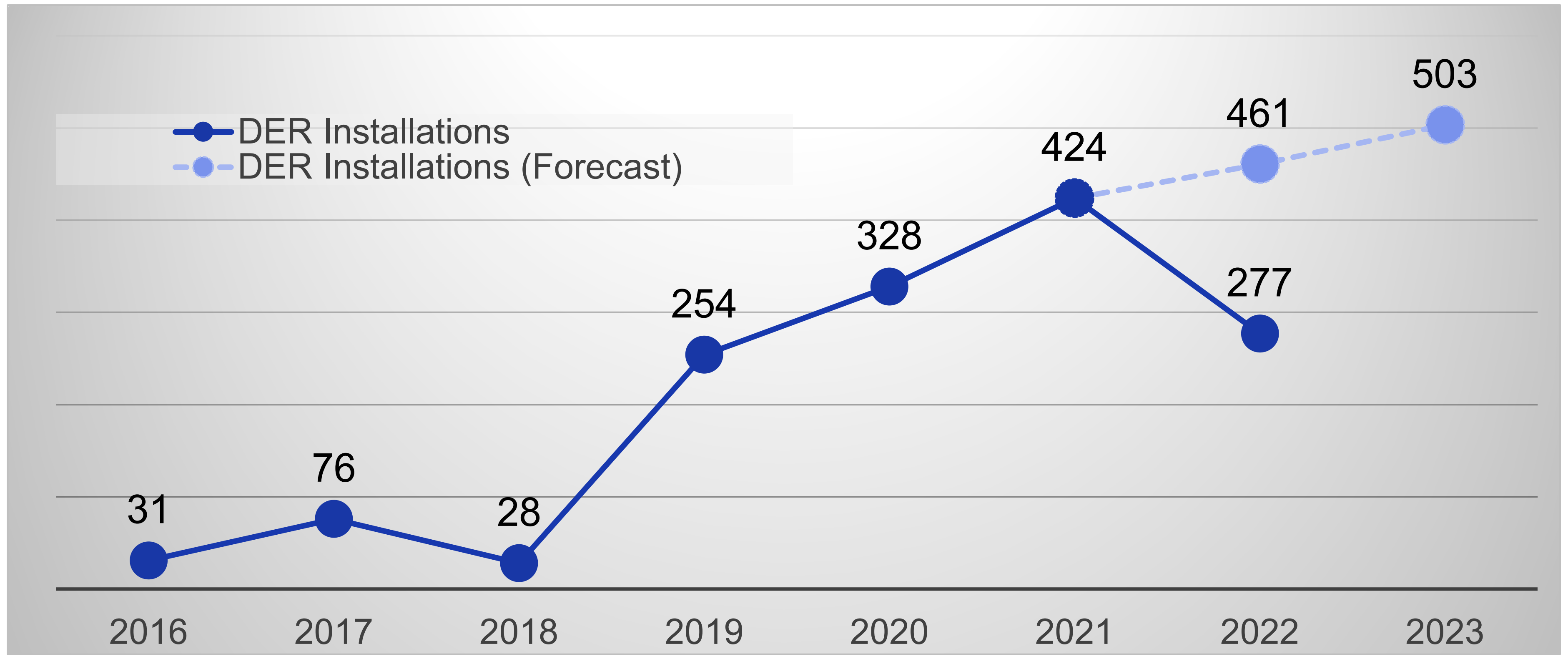


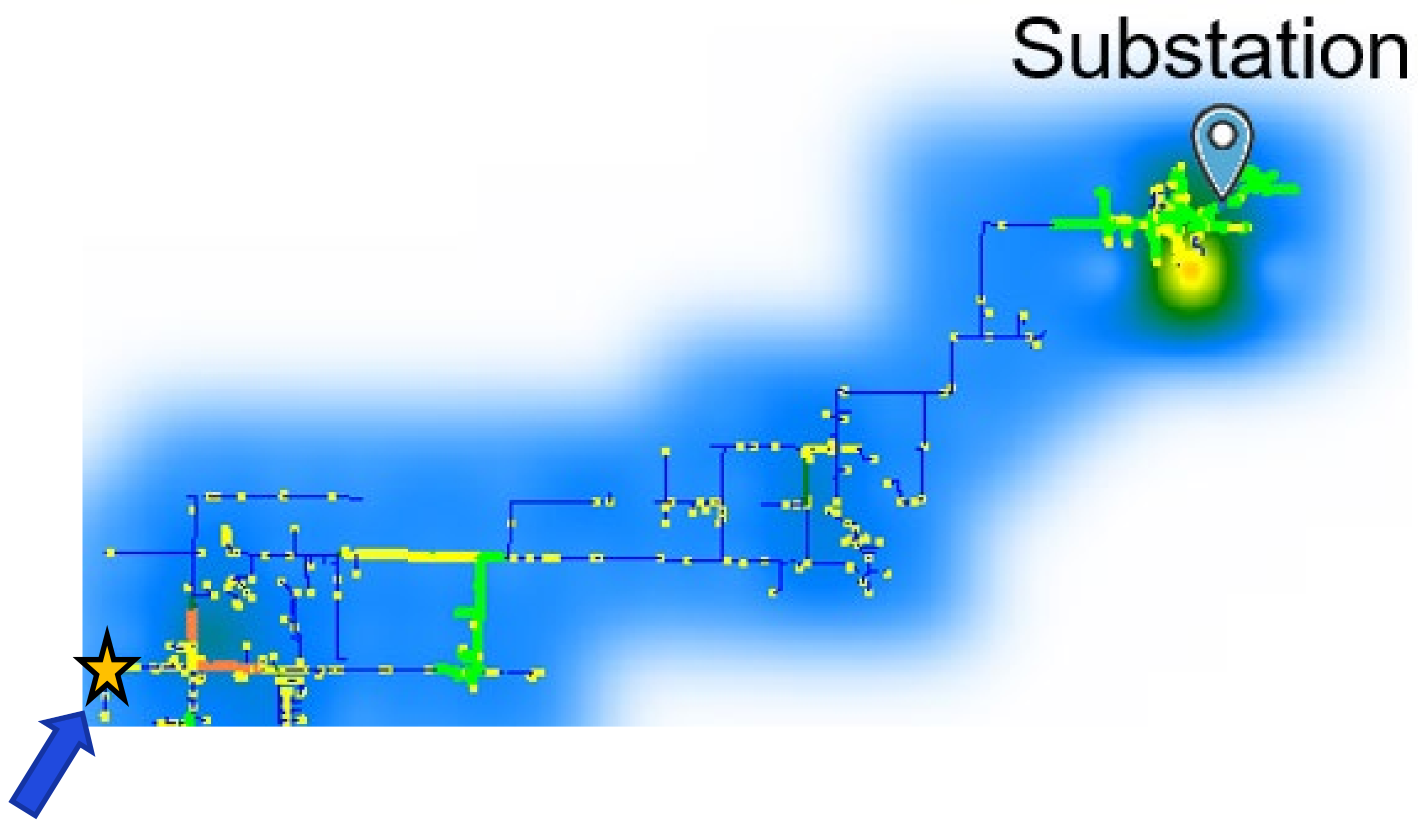
Form a Microgrid when the highlighted isolation device trips



Distributed Energy Resources

- Growing DERs on the system as result of lower costs, desire for renewable resources
- With an influx of DER on the system, DER will shift from a load modifier to a potential resource, solution to grid capacity issues, solution to voltage control, and other applications
- This presents opportunities for distribution system planning to think differently about capacity planning, voltage control, and utilization of non-traditional resources such as batteries in solution planning
- The advancement of power flow models and network modeling of the distribution systems will allow AES Indiana to study and make future recommendations on how we can extract maximum value to DER connected to the system





Targeted solar to solve thermal issue, part of planning toolbox

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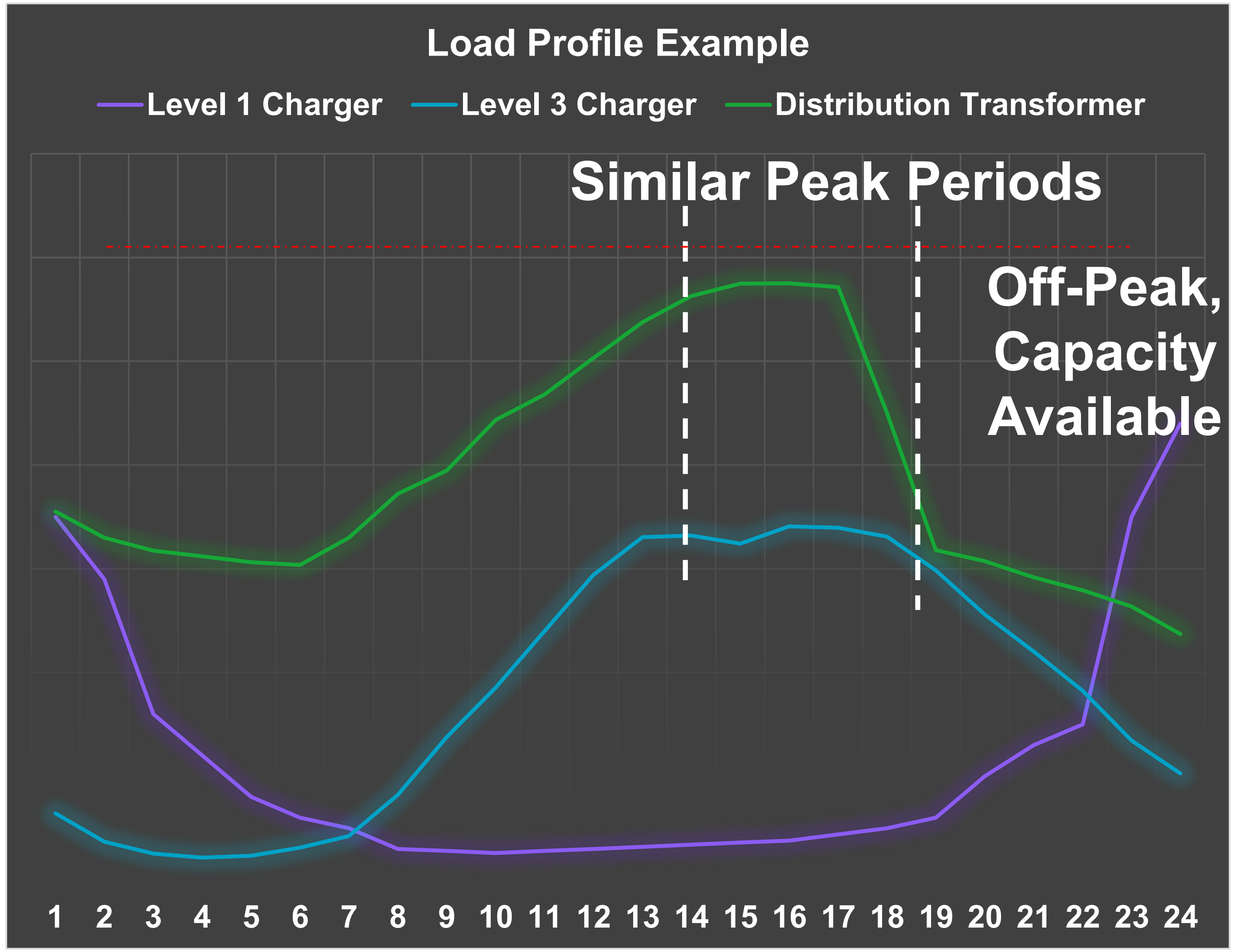
Electric Vehicles

Distribution planning considerations for electric vehicles (ev's)

- Level 1 and 2 charging are generally manageable for capacity planning assuming effective time of use (TOU) charging rates are in place.
- Level 3 charging is more problematic due to the peak load occurring simultaneously with the grid peak and at much higher magnitudes.
- Fleet charging requests have been limited but we see the potential for very large loads in this space that may have a major impact on system planning.

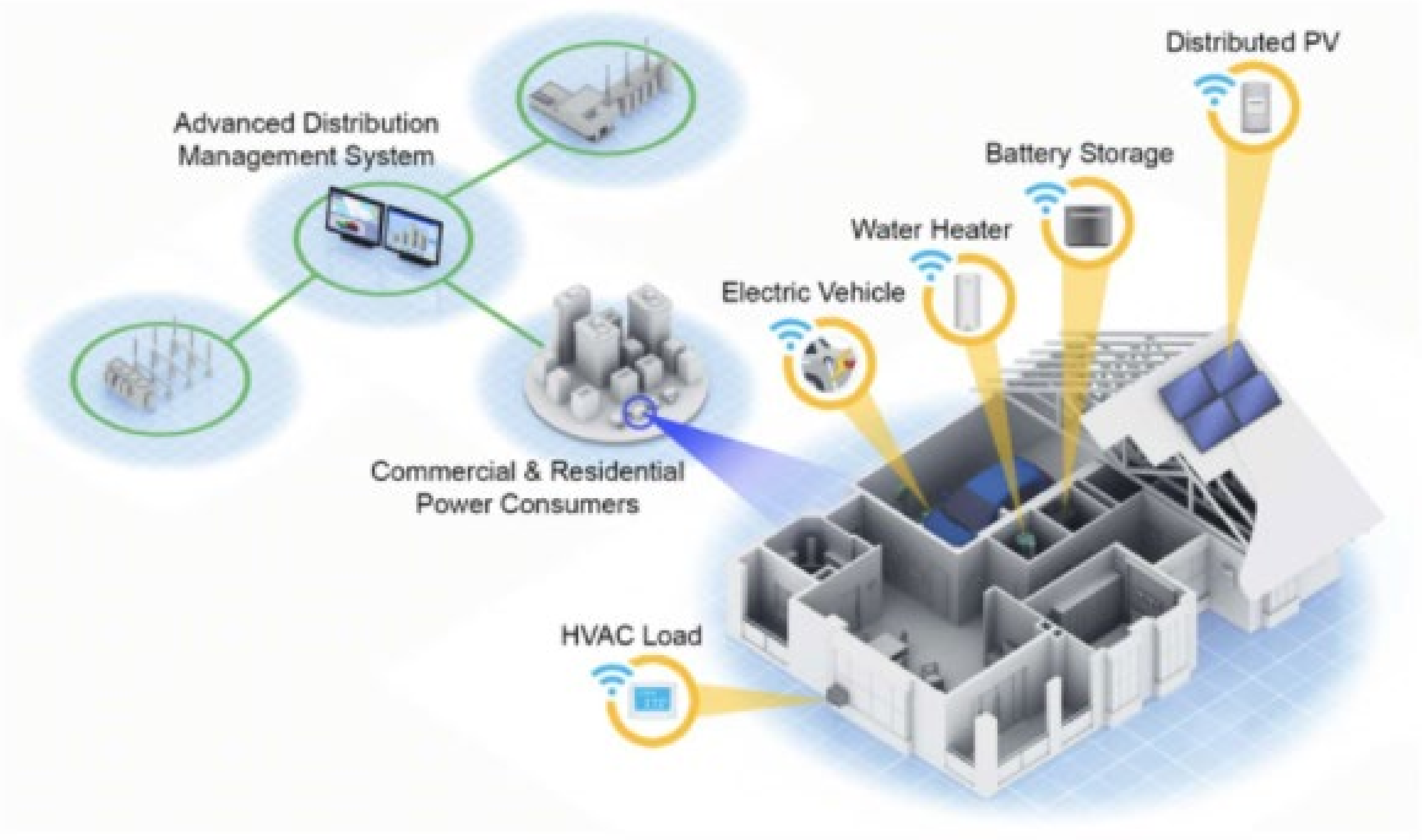


Demand forecasting & network modeling

- AES will account for EV growth by taking the resource planning top-down forecast and utilizing our demand forecasting parcel level EV propensity model to allocate it down to the circuits and feeders.
- AES will study the multiple scenarios developed around EV charging in our network models to determine if capacity upgrades will be required. In combination with other system needs on a particular circuit, there could be multiple ways to plan for solutions such as traditional asset upgrades, strategic battery placements, optimally placed circuit ties, optimal DER placements, etc.

FERC Order 2222

- **Distributed Energy Resource (DER):** Any resource connected to the distribution system
- **Demand Response (DR):** Any activity used to reduce load for wholesale market
- **DER Aggregation (DERA):** An aggregation of one or more DER/DRs participating together in wholesale markets
- **DER Aggregator:** The market participant for the DERA
- **A DERA is a virtual power plant** consisting of multiple smaller DER resources connected to the distribution system being offered into the MISO under one bid by an Aggregator



Importance of FERC Order 2222

→ FERC Order No. 2222 enables distributed energy resources (DERs) aggregators to compete in wholesale electric markets such as MISO

→ DERs can range from solar to battery storage, demand response, energy efficiency, thermal storage, electric vehicles and their charging equipment. DERs can locate on the distribution system and/or behind a customer meter

Distribution Planning Considerations:

- Distribution Aggregation studies will need to be completed.
- Furthers the need for connected T&D systems, processes, and interconnection portals as DER is integrated into MISO markets.
- Modernization of interconnection databases for tracking all DERs and their technical specifications.
- Potential for significant increases to DER interconnection study volumes, complexity, and size expected.
- Long-term forecasting of DERs, DERAs, and their performance impacts
- Potential need for distribution energy storage locally to manage the variability on each circuit.

Expedites and further justifies the need to expand smart grid operations & programs (AMI, ADMS, GIS, etc.).

- Basic levels of visibility and monitoring will be required for the continued safe operation of the system.
- Need to perform RTO day ahead and real time market studies with adequate visibility and monitoring.
- Enhancement of distribution system operator and market roles.

Conclusion

Strategic Organizational Alignment between Resource & T&D planning

Advanced Demand Forecasting, Connected top-down & bottom-up load forecasting

Advanced Modeling & Analysis, utilization of advanced power flow tools

Cutting-Edge Grid Operations, Utilization of ADMS to be Grid of the Future

Final Q&A and Next Steps

Public Advisory Meeting

Public Advisory Meeting #1	Public Advisory Meeting #2	Public Advisory Meeting #3	Public Advisory Meeting #4	Public Advisory Meeting #5
Jan. 24, 2022	**April 12, 2022**	**June 27, 2022**	**August 2022**	**October 2022**

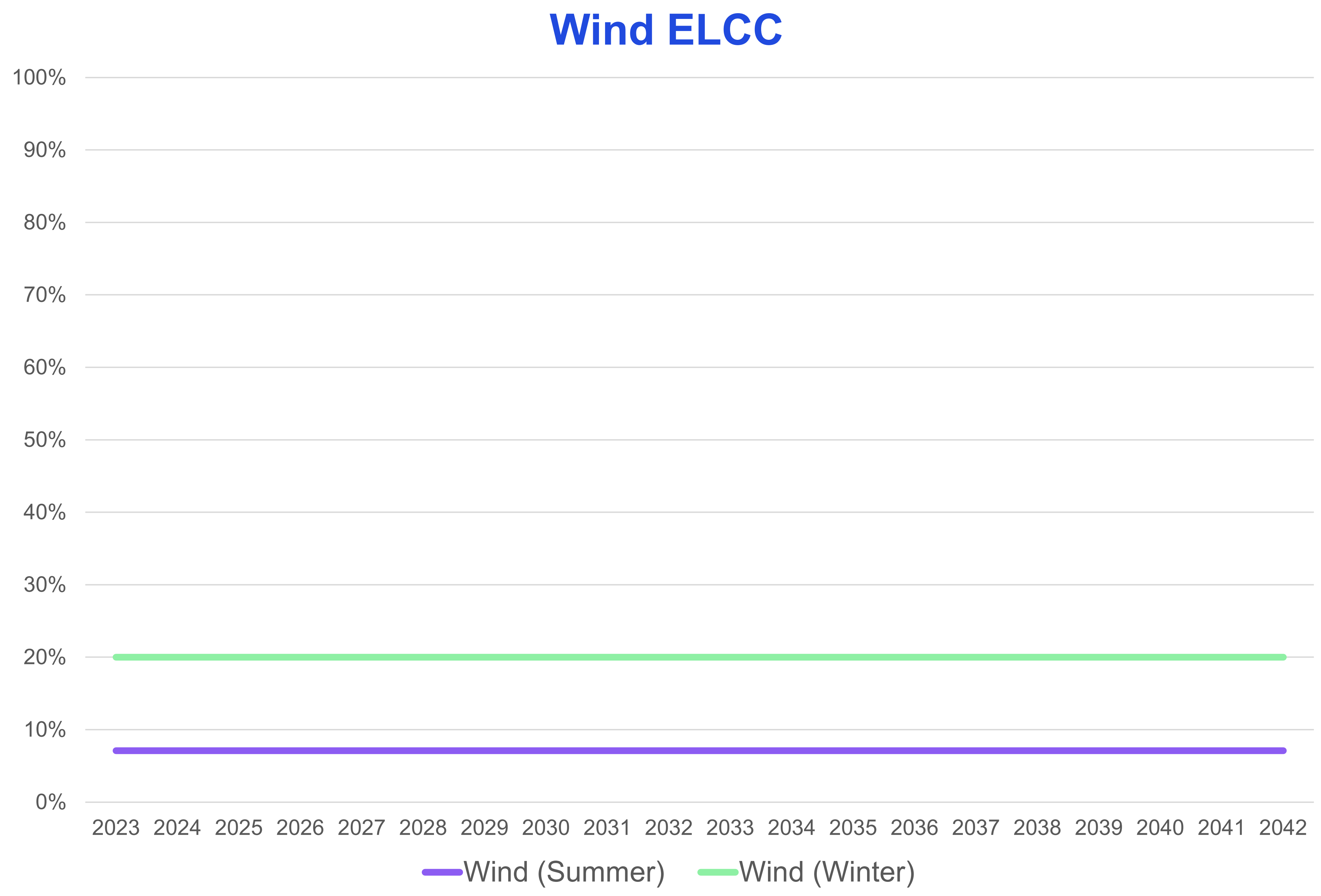
- All meetings will be available for attendance via Teams. Meetings in 2022 may also occur in-person.
- A Technical Meeting will be held the week preceding each Public Advisory Meeting for stakeholders with nondisclosure agreements. Tech Meeting topics will focus on those anticipated at the next Public Advisory Meeting.
- Meeting materials can be accessed at ***www.aesindiana.com/integrated-resource-plan.***

Thank You

Appendix

Wind Parameters

- **Location:** Indiana
- **Annual Capacity Factor:** 33.6 – 40.4%
- **Source Profile:** NREL System Advisory Model (SAM)
- **Project Size:** 50 MW ICAP
- **Useful Life:** 30 years
- **Summer ELCC (2025):** 7.1%; *Source: Horizons Energy*
- **Winter ELCC:** 20%; *Source: MISO RAN*



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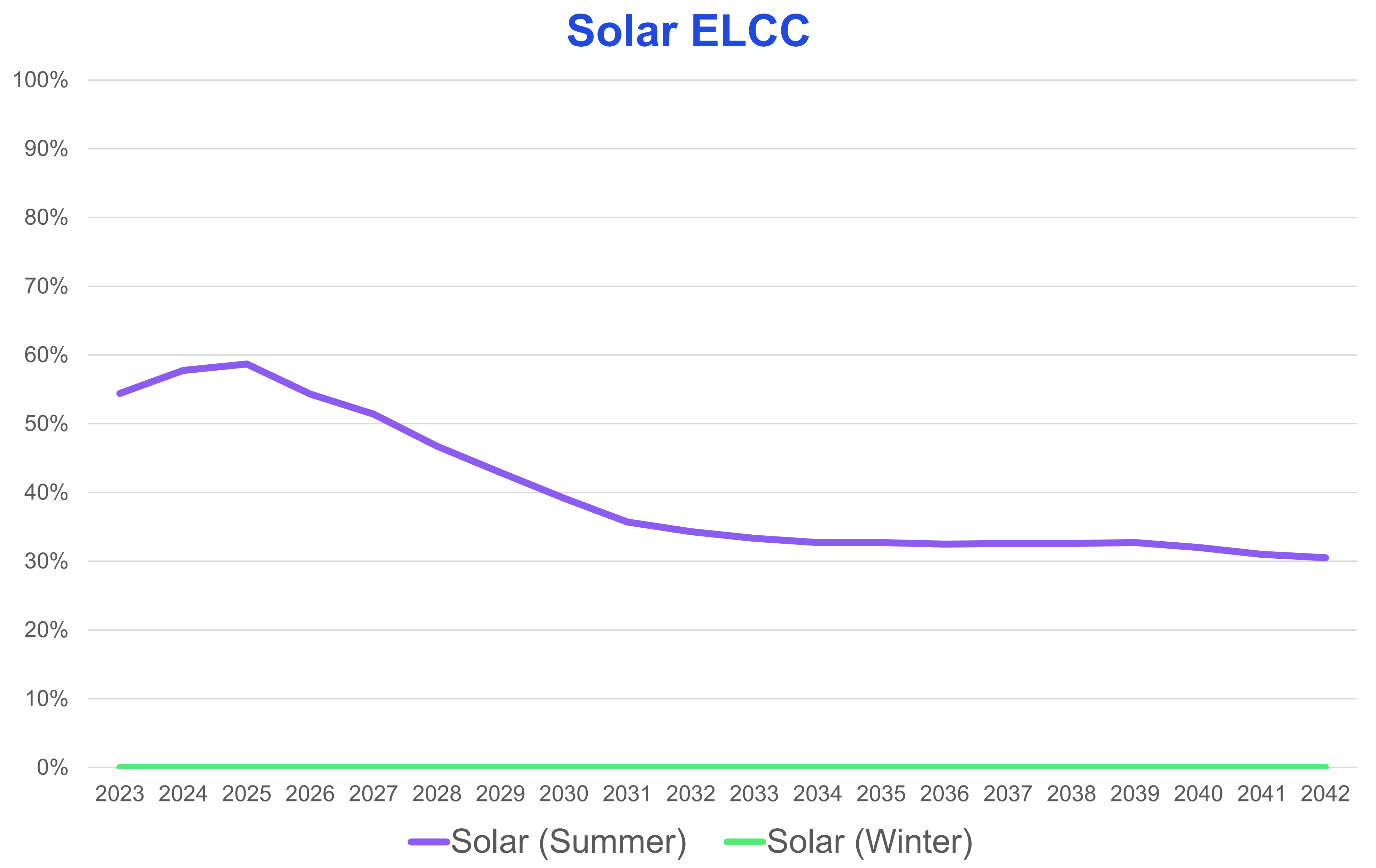
Solar Parameters

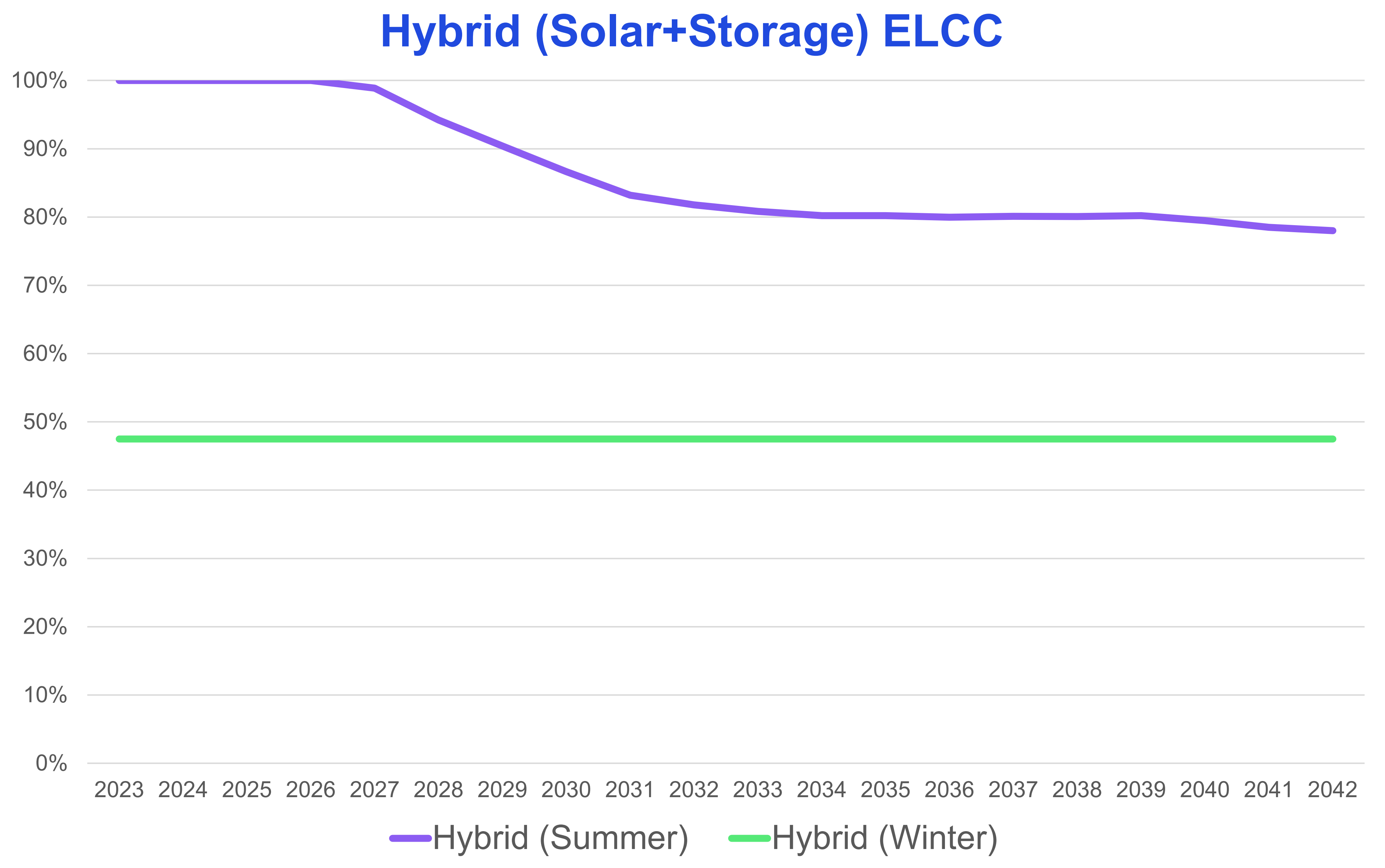
- **Location:** Petersburg, Indiana
- **Annual Capacity Factor:** 24.5%
- **Source Profile:** NREL System Advisory Model (SAM)
- **Project Size:** 25 MW ICAP
- **Useful Life:** 35 years
- **Summer ELCC (2025):** 58.7%; *Source: Horizon Energy*
- **Winter ELCC:** 0%; *Source: MISO RAN*



*Summer ELCC forecast presented in chart is from the Horizon Custom Reference Case – ELCC forecast will vary by custom scenario

Solar + Storage Parameters

- **Location:** Petersburg, Indiana
- **System:** DC Coupled Solar + Storage System, Storage charges exclusively from the solar array
- **Solar Component:** Identical to stand-alone solar (25 MW ICAP)
- **Storage Component:** 12.5 MW ICAP | 50 MWh
- **Synergies:** 4.3% reduction in capital costs, 2% improvement of RTE
- **Summer ELCC (2025):** 100%
- **Winter ELCC:** 48%



*Summer forecast presented in chart above is from the Horizon Custom Reference Case – forecast will vary by custom scenario

IRP Acronyms

Note: A glossary of acronyms with definitions is available at https://www.aesindiana.com/integrated-resource-plan.

IRP Acronyms

- ACEE: The American Council for an Energy-Efficient Economy
- AMI: Advanced Metering Infrastructure
- AD: Ad Valorem
- AD/CVD: Antidumping and Countervailing Duties
- ADMS: Advanced Distribution Management System
- BESS: Battery Energy Storage System
- BNEF: Bloomberg New Energy Finance
- BTA: Build-Transfer Agreement
- BTU: British Thermal Unit
- C&I: Commercial and Industrial
- CAA: Clean Air Act
- CAGR: Compound Annual Growth Rate
- CCGT: Combined Cycle Gas Turbines
- CCS: Carbon Dioxide Capture and Storage
- CDD: Cooling Degree Day
- CIS: Customer Integrated System
- COD: Commercial Operation Date
- CONE: Cost of New Entry
- CP: Coincident Peak
- CPCN: Certificate of Public Convenience and Necessity
- CT: Combustion Turbine
- CVD: Countervailing Duties
- CVR: Conservation Voltage Reduction
- DER: Distributed Energy Resource
- DERA: Distributed Energy Resource Aggregation
- DERMS: Distributed Energy Resource Management System
- DG: Distributed Generation
- DGPV: Distributed Generation Photovoltaic System
- DLC: Direct Load Control
- DOC: U.S. Department of Commerce
- DOE: U.S. Department of Energy
- DR: Demand Response
- DRR: Demand Response Resource
- DSM: Demand-Side Management
- DMS: Distribution Management System
- DSP: Distribution System Planning
- EE: Energy Efficiency
- EFORd: Equivalent Forced Outage Rate Demand
- EIA: Energy Information Administration
- ELCC: Effective Load Carrying Capability
- EM&V: Evaluation Measurement and Verification
- ESCR: Effective Selective Catalytic Reduction System
- EV: Electric Vehicle
- FLOC: Federated Learning of Cohorts
- GDP: Gross Domestic Product
- GFL: Grid-Following System
- GIS: Geographic Information System
- GT: Gas Turbine
- HDD: Heating Degree Day
- HVAC: Heating, Ventilation, and Air Conditioning
- IAC: Indiana Administrative Code
- IBR: Inverter-Based Resource
- IC: Indiana Code
- ICE: Intercontinental Exchange
- ICAP: Installed Capacity
- IEEE: Institute of Electrical and Electronics Engineers
- IRP: Integrated Resource Plan

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IRP Acronyms

- ICE: Internal Combustion Engine
- IQW: Income Qualified Weatherization
- ITC: Investment Tax Credit
- IURC: Indiana Regulatory Commission
- kW: Kilowatt
- kWh: Kilowatt-Hour
- MATS: Mercury and Air Toxics Standards
- MaxGen: Maximum Generation
- MDMS: Meter Data Management System
- MISO: Midcontinent Independent System Operator
- MPS: Market Potential Study
- MW: Megawatt
- NDA: Nondisclosure Agreement
- NOX: Nitrogen Oxides
- NPV: Net Present Value
- NREL: National Renewable Energy Laboratory
- NTG: Net to Gross
- OMS: Outage Management System
- PLL: Phase-Locked Loop
- PPA: Power Purchase Agreement
- PRA: Planning Resource Auction
- PSSE: Power System Simulator for Engineering
- PTC: Renewable Electricity Production Tax Credit
- PRMR: Planning Reserve Margin Requirement
- PV: Photovoltaic
- PVRR: Present Value Revenue Requirement
- PY: Planning Year
- RA: Resource Adequacy
- RAN: Resource Availability and Need
- RAP: Realistic Achievable Potential
- RCx: Retrocommissioning
- REC: Renewable Energy Credit
- REP: Renewable Energy Production
- RFP: Request for Proposals
- RIIA: MISO's Renewable Integration Impact Assessment
- RTO: Regional Transmission Organization
- SAC: MISO's Seasonal Accredited Capacity
- SAE: Small Area Estimation
- SCADA: Supervisory Control and Data Acquisition
- SCR: Selective Catalytic Reduction System
- SEM: Strategic Energy Management
- SO2: Sulfur Dioxide
- SMR: Small Modular Reactors
- ST: Steam Turbine
- SUFG: State Utility Forecasting Group
- T&D: Transmission and Distribution
- TOU: Time-of-Use
- TRM: Technical Resource Manual
- UCT: Utility Cost Test
- UCAP: Unforced Capacity
- VAR: Volt-Amp Reactive
- VPN: Virtual Private Network
- WTP: Willingness to Participate
- XEFORd: Equivalent Forced Outage Rate Demand excluding causes of outages that are outside management control