Welcome!

The meeting will start momentarily.

Questions during the presentation?

Questions can be taken over the audio bridge or submit a question to us in the chat function at any time.

Audio Details

All lines are muted. Following the presentation, unmute your line by selecting your Attendee Name and clicking the microphone icon. If you are dialing from a touch tone, you will press *6 to unmute your line.

Skype Layout

In the upper right corner, you can click the layout icon ( ) to select your preferred layout. To maximize your screen size, you can “X” the left-hand windows for “participants” and “conversation.” To re-enable this view, click on the participation icon.

IPL 2019 IRP: PUBLIC ADVISORY MEETING #1

January 29, 2019

WELCOME & OPENING REMARKS

Lisa Krueger

President, AES US SBU

MEETING OBJECTIVES & AGENDA

Stewart Ramsay

Meeting Facilitator

AGENDA

Topic	Time (EST)	Presenter
Welcome & Opening Remarks	9:30 - 9:40	Lisa Krueger, President, AES US SBU
Meeting Agenda & Guidelines	9:40 - 9:50	Stewart Ramsay, Meeting Facilitator
2016 IRP Review	9:50 - 10:10	Patrick Maguire, Director of Resource Planning
2019 IRP: Timeline, Mission, Objectives	10:10 - 10:30	
BREAK	10:30 - 10:45	
Capacity Discussion: ICAP, UCAP, Capacity Factor, Economic Min/Max	10:45 - 11:30	Patrick Maguire, Director of Resource Planning
2019 IRP Starting Point: IPL Load and Resources	11:30 - 12:00	
LUNCH	12:00 - 12:45	
Ascend Analytics PowerSimm Model	12:45 - 1:30	David Millar, Ascend Analytics
Modeling Replacement Resources	1:30 - 2:15	Patrick Maguire, Director of Resource Planning
BREAK	2:15 - 2:30	
DSM/EE Modeling and Load Forecast Update	2:30 - 3:00	Erik Miller, Senior Research Analyst
Concluding Remarks & Next Steps	3:00 - 3:15	Patrick Maguire, Director of Resource Planning

2016 IRP RECAP

Patrick Maguire

Director of Resource Planning

2016 IRP SUMMARY

Meeting 1 (April)	Meeting 2 (June)	Meeting 3 (August)	Meeting 4 (September)
• Supply Side and Distributed Resources • Demand Side Resources • DSM Modeling • Risk Discussion • Scenario Workshop	• Metrics Exercise • Resource Adequacy • IPL T&D • Load Forecast • Environmental Risks • Portfolio Exercise	• IRP Modeling Update • Sensitivity Analysis and Stochastic Setup	• Final Model Results • Metrics & Sensitivity Analysis Results • Analysis Observations • Short Term Action Plan

Report Filed on November 1, 2016

All presentations, materials, and reports can be found on IPL's website.

Joint Utilities Integrated Resource Plan (IRP): Stakeholder Education Session

Indiana IOUs jointly presented an educational session to discuss the IRP process. All materials can be found here.

2016 IRP: COMMENTS AND IMPROVEMENTS TARGETED

Topic	Comments Summary (not exhaustive)	2019 IRP Improvements
Commodity Forecasts	• Not enough narrative and underlying fundamental support data to support commodity price forecasts • Base forecast inconsistent with changing market fundamentals and trends • Changing resource mix and other fundamentals could materially change	• Scenarios will be built around varying commodity assumptions, with all supporting data clearly outlined • Narrative and thorough set of supporting data will be provided well in advance of Nov. 1st filing date • Data will be made available with signed NDA and public whenever possible
Scenarios and Portfolios	• Unclear modeling framework with regards to scenarios, portfolios, and stochastics • All portfolios weighed against base case assumptions • Preferred plan not optimized in capacity expansion	• March 13th Meeting will outline comprehensive scenario modeling framework to address concerns in 2016 IRP • Modeling types will be clearly identified and discussed (i.e. portfolios vs scenarios, optimized vs fixed portfolios, capacity expansion vs production cost model)

2016 IRP: COMMENTS AND IMPROVEMENTS TARGETED (CONT'D)

Topic	Comments Summary (not exhaustive)	2019 IRP Improvements
Metrics	• Stochastic results not fully integrated with metrics scorecard and used in a limited manner • No specific metrics related to portfolio diversity • Environmental metrics should also include land and water impacts	• IPL's move to Ascend Analytics' PowerSimm will enable IPL to more fully incorporate stochastic results into the metrics process • Metrics and risk analysis will be conducted using the same set of underlying data from PowerSimm • IPL will consider additional environmental metrics
DSM/EE Modeling	• Inconsistent avoided cost values • Only two DSM/EE decision points considered • Assumptions on future DSM costs need to be reviewed	• New model will allow for more DSM bundles and decision points • IPL considering alternative approaches to accounting for changes in future DSM costs • Avoided costs will be consistent and presented clearly in meetings and/or provided data files

INTRODUCTION TO THE 2019 IRP

Patrick Maguire

Director of Resource Planning

IPL 2019 IRP

INTEGRATED RESOURCE PLAN (IRP):
IPL's plan to provide safe, reliable, and sustainable energy solutions for the communities we serve

- IRP submitted every three years
- Plan created with stakeholder input
- 20-year look at how IPL will serve load
- Modeling and analysis culminates in a preferred resource portfolio

What is a preferred resource portfolio?

" 'Preferred resource portfolio' means the utility's selected long term supply-side and demand-side resource mix that safely, reliably, efficiently, and cost-effectively meets the electric system demand, taking cost, risk, and uncertainty into consideration."

IURC RM #15-06, LSA Document #18-127
Link (PDF): https://www.in.gov/iurc/files/RM_ord_20181024141710007.pdf

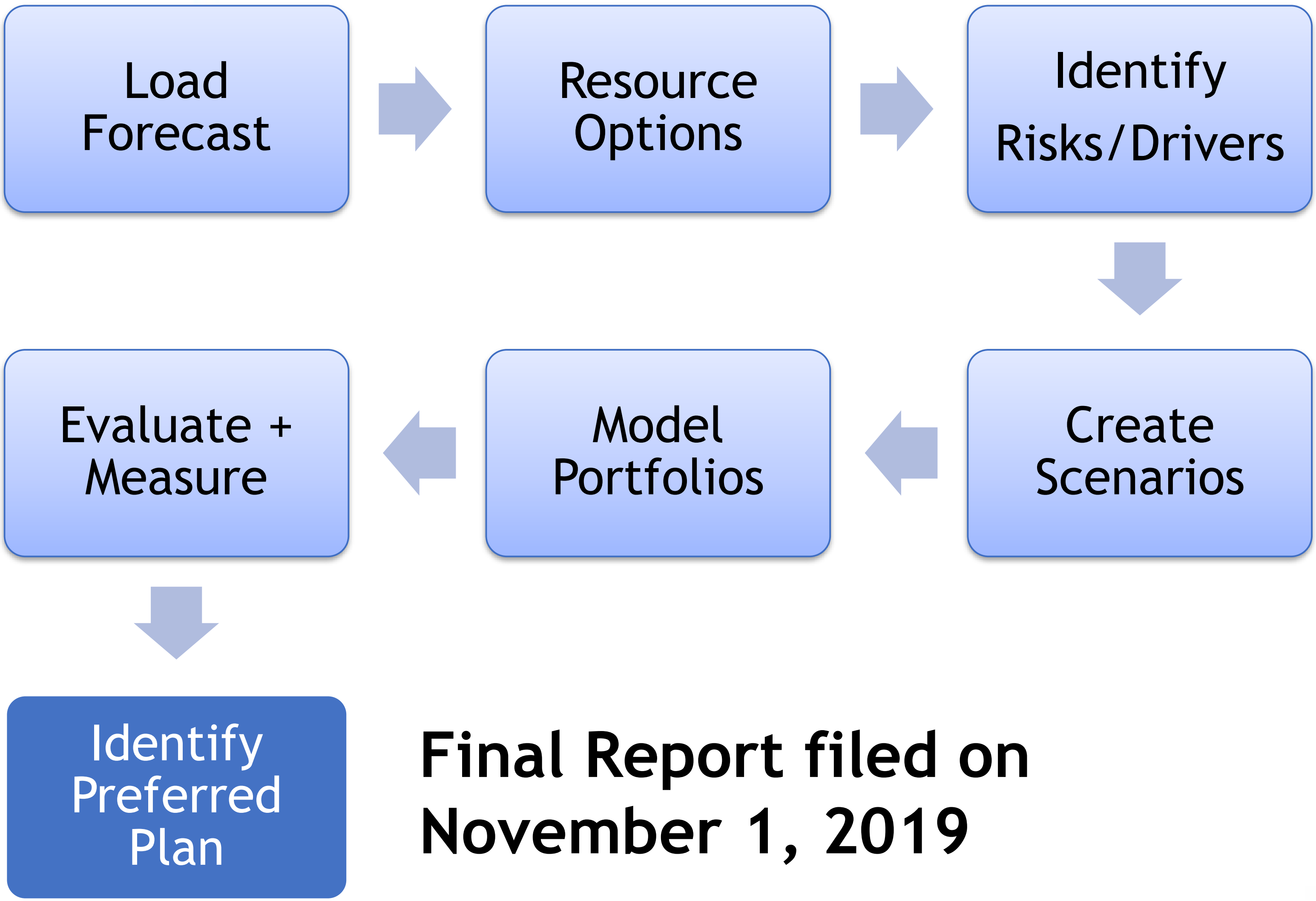
2019 IRP STAKEHOLDER PROCESS

Dates to follow for meetings #3-5

January 29th	March 13th	May	August	October
•2016 IRP Recap •2019 IRP Timeline, Objectives, Stakeholder Process •Capacity Discussion •IPL Existing Resources and Preliminary Load Forecast •Introduction to Ascend Analytics •Supply-Side Resource Types •DSM/Load Forecast Schedule	•Stakeholder Presentations •Commodity Assumptions •Capital Cost Assumptions •IPL-Proposed Scenario Framework •Scenario Workshop •MPS Update and Plan	•Stakeholder Presentations •Summary of Stakeholder Feedback •Present Final Scenarios •Modeling Update •Assumptions Review and Updates	•Stakeholder Presentations •Summary of Stakeholder Feedback •Preliminary Model Results •Scenario Descriptions and Results •Preliminary Look at Risk Analysis and Stochastics	•Stakeholder Presentations •Final Model Results •Scenario Updates •Updates on Stakeholder Scenarios •Preferred Plan

IPL is committed to conducting a robust and collaborative stakeholder process. Multiple communication avenues will be provided to ensure that all stakeholders have the opportunity to be a part of the 2019 IRP process.

IRP PROCESS OVERVIEW



Final Report filed on November 1, 2019

ipl
an AES company

2019 IRP PARTNERS AND RESOURCES

Key Partners

Ascend Analytics
Better models. Better decisions.

Itron

GDS Associates, Inc.
ENGINEERS & CONSULTANTS

CONCENTRIC
ENERGY ADVISORS

VANRY
ASSOCIATES

Resources

IHS Markit™

Wood Mackenzie
POWER & RENEWABLES

ABB

Energy
S&P Global
Market
Intelligence

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Bloomberg
NEW ENERGY FINANCE

eia
Independent Statistics & Analysis
U.S. Energy Information
Administration

BREAK

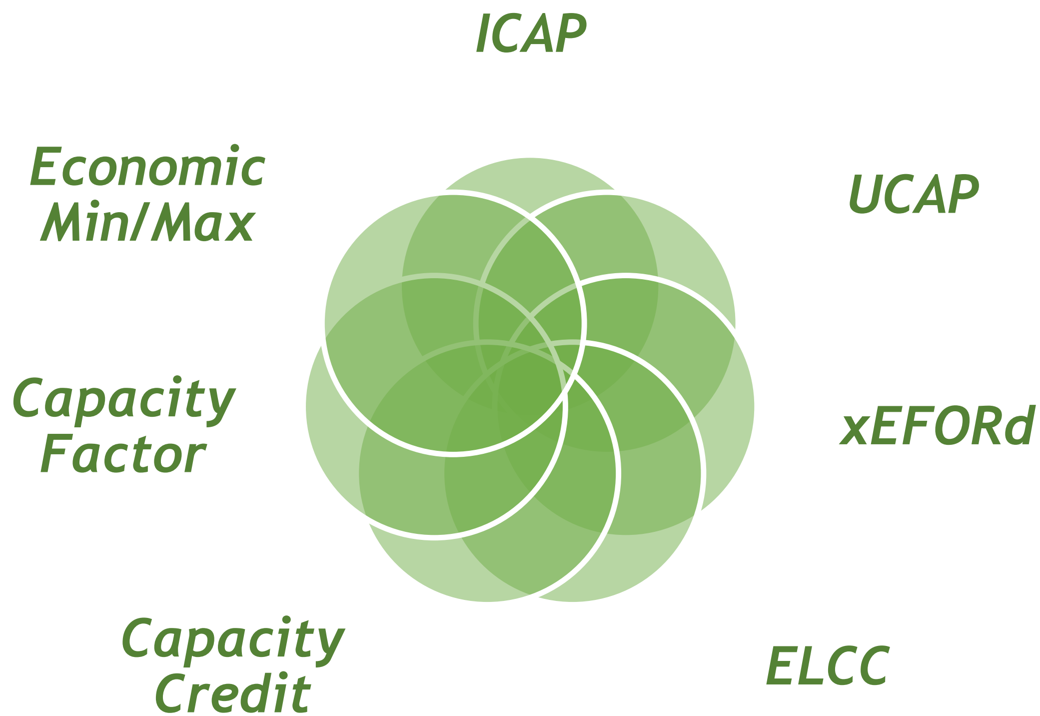
CAPACITY: DEFINING COMMON IRP MODELING TERMS

Patrick Maguire

Director of Resource Planning

CAPACITY DEFINITIONS

Goal: Define capacity terms in IRP modeling to provide transparency and clarity in presentations, analysis, and reporting



ICAP

ICAP = INSTALLED CAPACITY

Installed Capacity, or ICAP, refers to the generating capacity after ambient weather adjustments and before forced outage adjustments

Examples:

- “The county will be the home of a new 100 MW wind farm…”
- “Deal signed for 200 MW solar farm…”
- “1,000 MW of natural gas-fired capacity…”

XEFORD

xEFORd = Equivalent Demand Forced Outage Rate excluding some outages

Per MISO BPM-011, Section 3.5.4*:

Equivalent demand Forced Outage Rate (EFORd): A measure of the probability that a generating unit will not be available due to forced outages or forced deratings when there is demand on the unit to generate.

XEFORd: Same meaning as EFORd, but calculated by excluding causes of outages that are Outside Management Control (OMC). For example, losses of transmission outlet lines are considered as OMC relative to a unit's operation.

* BPM-011 – Resource Adequacy can be found at https://www.misoenergy.org/planning/resource-adequacy

Planning Year 2018-2019 Pooled EFORd Class	Pooled EFORd (%)	Data Source
Combined Cycle	5.37	MISO
Combustion Turbine (50+ MW)	5.18	MISO
Diesel Engines	10.26	MISO
Steam - Coal (200-400 MW)	9.82	MISO
Steam - Coal (400-600 MW)	9.28	MISO*
Steam - Coal (600-800 MW)	8.22	MISO
Steam - Coal (800-1000 MW)	9.28	MISO*
Steam - Gas	11.56	MISO

For new units with less than 12 months of operational data, a pooled class-average xEFORd% is provided by MISO.

Link: MISO PY 19/20 Resource Adequacy Documents

ELCC

ELCC = Effective Load Carrying Capability = Capacity Credit

Per MISO Wind & Solar Capacity Credit Report, Section 2.1*:

> *Effective Load Carrying Capability (ELCC) is defined as the amount of incremental load a resource, such as wind, can dependably and reliably serve, while also considering the probabilistic nature of generation shortfalls and random forced outages as driving factors to load not being served.*

Translation: what percent of a wind resource's total capacity (ICAP) is actually being produced at the time of the summer peak load?

* MISO Wind & Solar Capacity Credit Report, December 2018 (PDF):
https://cdn.misoenergy.org/2019%20Wind%20and%20Solar%20Capacity%20Credit%20Report303063.pdf

UCAP

UCAP = UNFORCED CAPACITY = FIRM CAPACITY = PLANNING CAPACITY

Unforced capacity, or UCAP, is a unit's generating capacity adjusted down for forced outage rates (thermal resources) or expected output during the peak load (intermittent resources).

THERMAL RESOURCE EXAMPLE

ICAP = 100 MW
xEFORd = 10%
*UCAP = ICAP * (1 – xEFORd)*
UCAP = 100 * (1- .1) = 90 MW

For Solar:
Capacity Credit = ELCC%
until MISO conducts a formal ELCC study

WIND AND SOLAR EXAMPLES

Wind
ICAP = 100 MW
ELCC % = 7%
*UCAP = ICAP * ELCC*
UCAP = 100 * .07 = 7 MW

Solar
ICAP = 100 MW
Capacity Credit = 50%
*UCAP = ICAP * Capacity Credit*
UCAP = 100 * .5 = 50 MW

ICAP VS UCAP: EXAMPLES

ICAP = Installed Capacity	UCAP = Unforced Capacity

		ICAP MW	UCAP MW
Thermal Unit (e.g. Coal, Gas)	10% xEFORd	100	90
Wind	7.8% Zone 6 ELCC	100	7.8
Solar	50% credit	100	50
4-Hour Storage *100 MW, 400 MWh*	5% xEFORd	100	95
1-Hour Storage *100 MW, 100 MWh*	5% xEFORd	100	23.8

ICAP VS UCAP: EXAMPLES

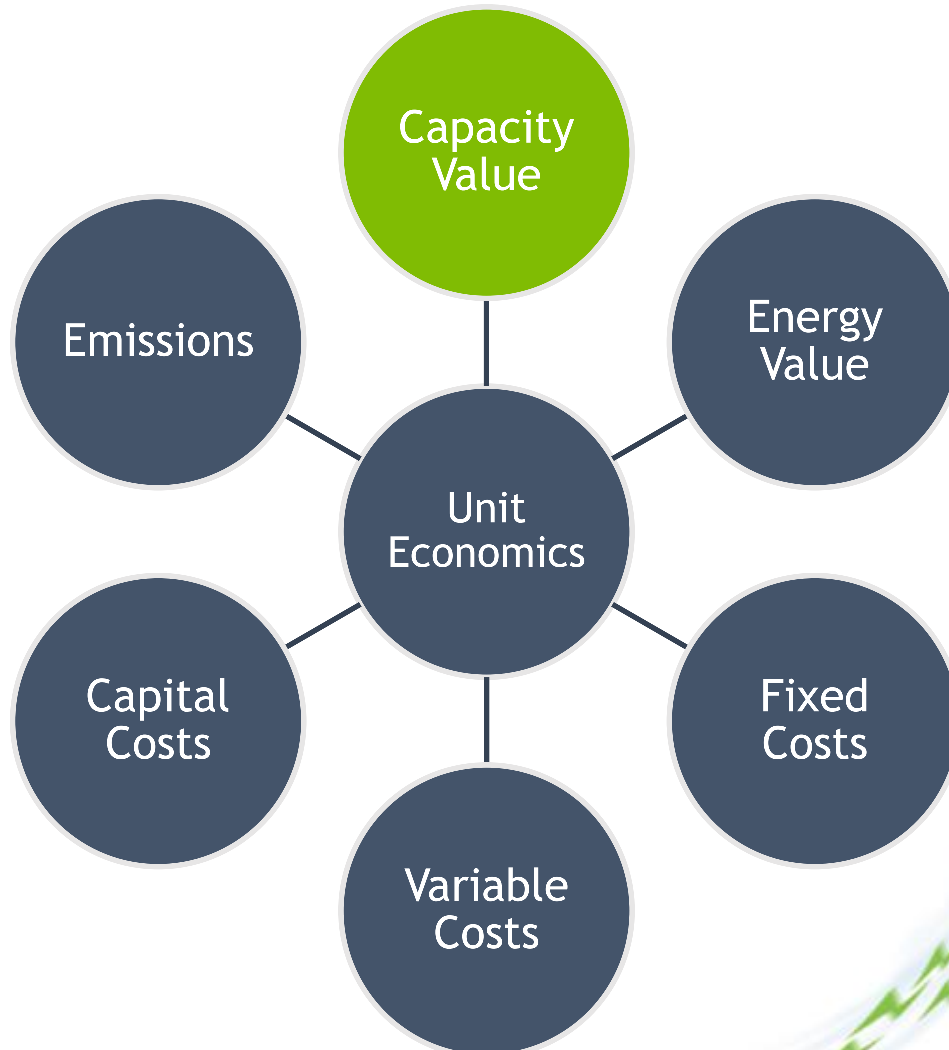
ICAP = Installed Capacity   UCAP = Unforced Capacity

To Cover a 1,000 MW UCAP Shortfall:

	ICAP MW	UCAP MW	ICAP MW Required
Thermal	100	90	1,111
Wind	100	7.8	12,821
Solar	100	50	2,000
4-Hour Storage	100	95	1,053
1-Hour Storage	100	23.8	4,202

CAPACITY: ONLY ONE PIECE OF RESOURCE VALUATION PUZZLE

Important to note that the UCAP contribution of a resource type is only one part of the valuation process.



ECONOMIC DISPATCH CAPACITY

Economic Minimum

Minimum amount of MW available for economic dispatch in the market

Economic Maximum

Maximum amount of MW available for economic dispatch in the market

Economic Min/Max: for thermal units, the MW limits used for dispatch modeling in the IRP

- Can be different than ICAP and UCAP
- Closely aligned with IPL Commercial Group that offers the units in MISO
- Can change daily due to ambient weather conditions, operational constraints at the plant, and other factors

CAPACITY FACTOR: INPUT OR OUTPUT?

Definition via EIA:
The ratio of the electrical energy produced by a generating unit for the period of time considered to the electrical energy that could have been produced at continuous full power operation during the same period.

- **Wind and Solar:** Input to the model via monthly energy targets and profiles
- **Thermal units:** Output from the model via hourly economic dispatch

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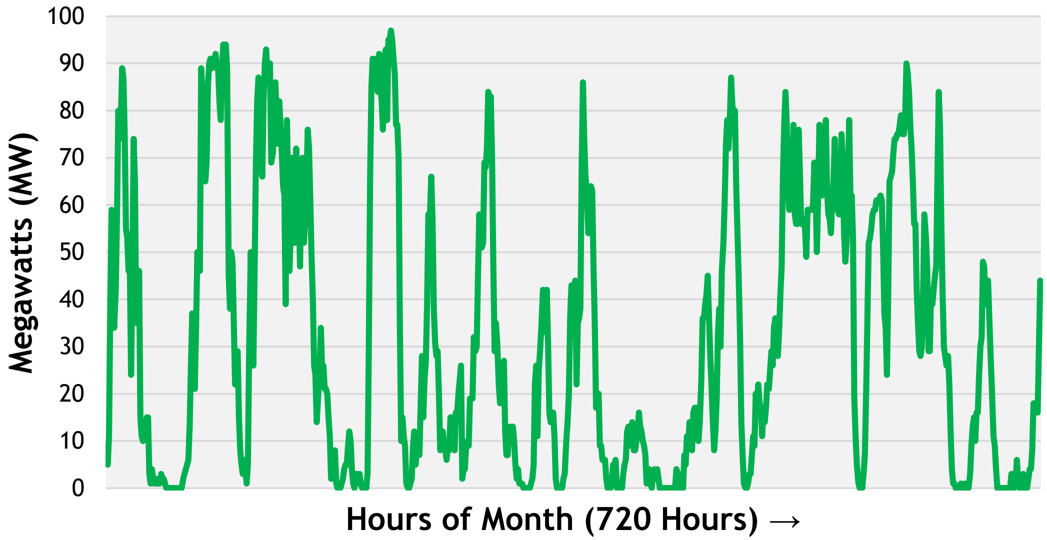
Example: 100 MW Wind Farm
November Hourly Profile



Wind Farm Capacity (ICAP) = 100 MW

Monthly Total Energy = 23,500 MWh

Maximum Energy = 720 hours x 100 MW = 72,000 MWh

Capacity Factor = Actual MWh / Max Potential MWh

Monthly Capacity Factor = 23,500 / 72,000 = 32.6%

2019 IRP STARTING POINT: IPL LOAD AND RESOURCES

Patrick Maguire

Director of Resource Planning

IPL'S CHANGING RESOURCE MIX

2009 - 2018

2009

Signed 100 MW PPA at Hoosier Wind Park in NW Indiana

2011

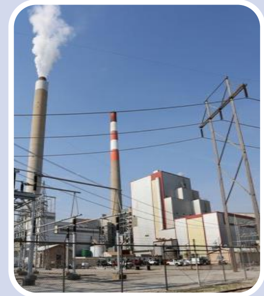
Signed 200 MW PPA at Lakefield Wind Farm in Minnesota

2013-2015

Signed 96 MW PPA for solar in Indianapolis through Rate REP

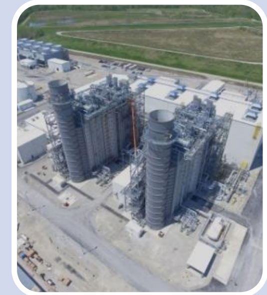
2016

Retired 260 MW of coal at Eagle Valley



2016

Finalized conversion of 630 MW of coal-fired generation at Harding Street to natural gas

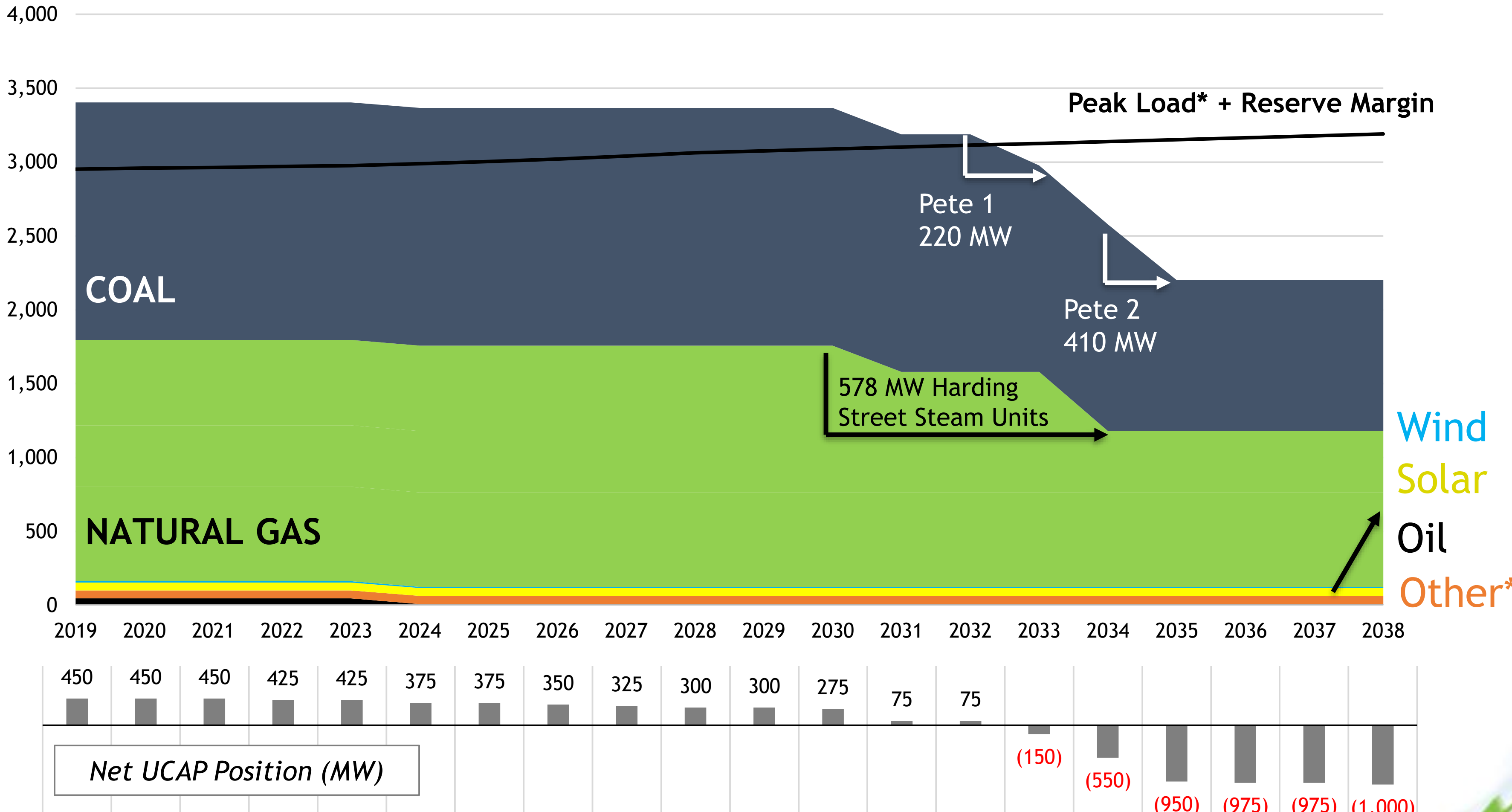


2018

Eagle Valley 671 MW Gas-Fired Combined Cycle Plant Completed

IRP STARTING POINT

IPL NET LONG CAPACITY THROUGH 2032 WITH AGE-BASED RETIREMENT SCHEDULES



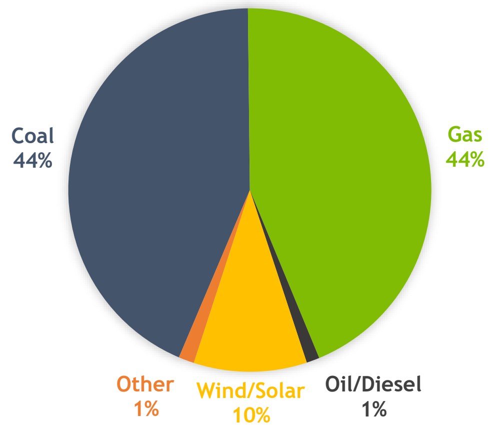
ALL CAPACITY SHOWN IN UCAP MW
* Other: ACLM (37 MW), CVR (17 MW), Rider 17 (1 MW)

* *Preliminary peak load forecast*

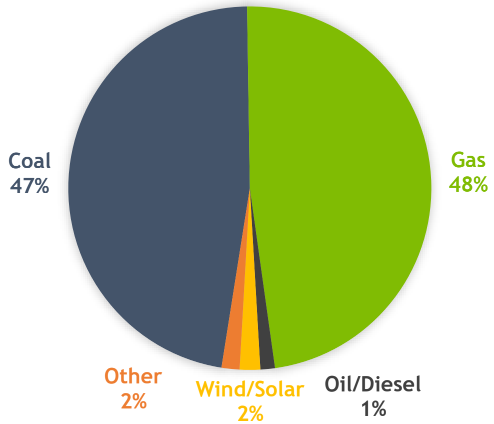
IPL RESOURCES: SUMMARY

	ICAP	UCAP
Coal	1,706	1,608
Gas	1,725	1,634
Oil/Diesel	47	44
Wind/Solar	396	62
Other	54	54
Total	3,929	3,402

% of ICAP



% of UCAP



ICAP = Installed Capacity UCAP = Unforced Capacity

IPL RESOURCES: NATURAL GAS

Unit	Name	Type	ICAP MW	UCAP MW	Avg HR @ Max (MMBtu/MWh)	In-Service Year	Estimated Last Year In-Service
Eagle Valley							
EV CCGT	Eagle Valley	CCGT	671	640	6.7	2018	2068
Harding Street							
HS 5G	Harding Street 5	Gas ST	95	90	10.5	1958	2030
HS 6G	Harding Street 6	Gas ST	95	90	10.5	1961	2030
HS 7G	Harding Street 7	Gas ST	422	400	9.7	1973	2033
HS GT4	Harding Street GT4	Gas CT	71	67	12.4	1994	2044
HS GT5	Harding Street GT5	Gas CT	72	68	12.4	1995	2045
HS GT6	Harding Street GT6	Gas CT	145	134	10.0	2002	2052
Georgetown							
GTOWN GT1	Georgetown 1	Gas CT	76	71	12.4	2000	2050
GTOWN GT4	Georgetown 4	Gas CT	78	75	12.4	2001	2052

Unit Type	UCAP
Combined Cycle (CCGT)	640 MW
Steam Turbine (ST)	578 MW
Combustion Turbine (CT)	415 MW

Total Natural Gas UCAP: 1,634 MW

IPL RESOURCES: WIND AND SOLAR

Name	Type	ICAP MW	UCAP MW	PPA Start	PPA Expiration
Hoosier Wind Park (IN)	PPA	100	7.8	Nov-09	Nov-29
Lakefield Wind (MN)	PPA	200	0	Oct-11	Oct-31
Solar (Rate REP)	PPA	96	54	*varies*	*varies*

- **Wind PPA Modeling Assumption:** assuming that projects continue to be in the IPL Portfolio past PPA term
- **Lakefield Wind:** no firm transmission
- **IPL Solar Capacity Credit:** credit if greater than 50% because it is netted against peak load forecast rather than registered as a separate resource in MISO

Total Renewable ICAP:
396 MW

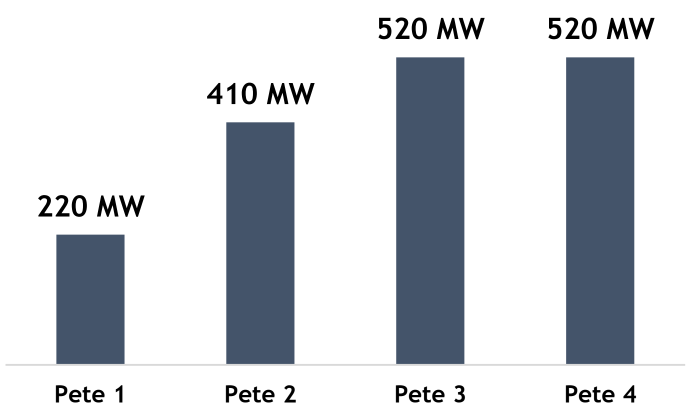
Total Renewable UCAP:
62 MW

IPL RESOURCES: COAL

Unit	Name	Type	ICAP MW	UCAP MW	Avg HR @ Max (MMBtu/MWh)	In-Service Year	Estimated Last Year In-Service
Petersburg							
PETE ST1	Pete 1	Coal	220	210	10.36	1967	2032
PETE ST2	Pete 2	Coal	417	376	10.36	1969	2034
PETE ST3	Pete 3	Coal	532	497	10.43	1977	2042
PETE ST4	Pete 4	Coal	537	524	10.55	1986	2042

Total Coal ICAP:
1,706 MW

Total Coal UCAP:
1,608 MW



Framework for scenario analysis will be presented at the March 13th meeting

INTRODUCTION TO ASCEND ANALYTICS

Patrick Maguire

Director of Resource Planning

Ascend Analytics
Better models. Better decisions.

Presentation to IPL 2019 IRP Stakeholders
Ascend Analytics and PowerSimm Intro

David Millar
Director of Resource Planning Consulting

January 29, 2019

ipl® an AES company

AGENDA

- Introduction to Ascend
- PowerSimm Product Suite
- What makes Ascend and PowerSimm different?
- Deterministic vs Stochastic
- Q&A

About Ascend Analytics

- Founded in 2002 with over 50 employees in Boulder, Oakland, and Bozeman
- Seven integrated software products for operations, portfolio analytics, and planning
- Custom analytical solutions and consulting

Proven and Broadly Adopted

American Electric Power (AEP) · Austin Energy · Los Angeles Department of Water & Power · Duke Energy · PNM · NorthWestern Energy · Hawaiian Electric Company · New York Power Authority

Differentiated Value

PowerSimm OPS
OPERATIONAL STRATEGY

1 to 10 days

- Forecast short-term loads and market prices with uncertainty
- Determine operating strategies from position and financial exposure
- Track realized customer revenue and costs to settled day ahead and real time price
- Optimize financial exposure between day ahead and real time prices

PowerSimm Portfolio Manager
PORTFOLIO MANAGEMENT

1 month to ≈ 5 years

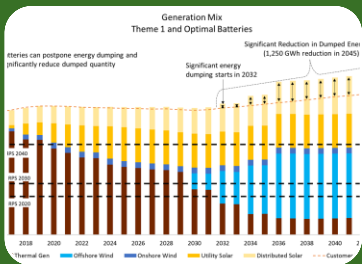
- Budgeted cash flows equal realized cash flows
- Management of retail load risk with volumetric and market price uncertainty
- Impact of hedges on reducing cash flow uncertainty
- Retail management & pricing
- Portfolio management with analytics insight to manage risk (CFaR, GMaR, EaR)
- Track portfolio performance of retail contracts and hedges with settled prices

PowerSimm Planner
LONG-TERM PLANNING

5 to 30 years

- Resource Planning
- Optimal expansion planning
- Renewable integration
- Reliability Analysis
- Renewable Integration
- Cost versus risk tradeoff resource analysis
- Battery storage optimization
- Financial Analysis

Ascend Analytics expertise in long-term planning

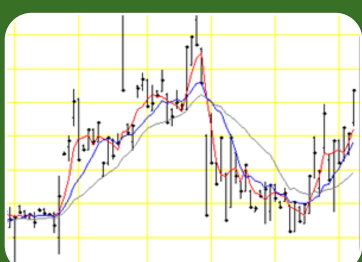


Integrated Resource planning

- Resource selection
- Reliability analysis
- Renewable integration
- Energy storage

Regulatory and stakeholder support

- Testimony and interrogatory
- Expert witness



Fundamental and Market Analysis

- Changing market dynamics
- Long-term forward curves
- Day-ahead and real-time

PowerSimm Suite: Short-, Intermediate, Long-term

A full, end-to-end solution

PowerSimm OPS OPERATIONAL STRATEGY	PowerSimm Portfolio Manager PORTFOLIO MANAGEMENT	PowerSimm Planner LONG-TERM PLANNING
1 to 10 days	**1 month to ≈ 5 years**	**5 to 30 years**
• Forecast short-term loads and market prices • Optimize financial exposure between DA and RT prices • Provide continuous bid optimization • Track realized customer revenue and costs to settled DA and RT price	• Budgeted cash flows equal realized cash flows • Management of retail load risk with volumetric and market price uncertainty • Impact of hedges on reducing cash flow uncertainty • Retail management & pricing • Portfolio management with analytics insight to manage risk (CFaR, GMaR, EaR) • Track portfolio performance of retail contracts and hedges with settled prices	• Resource planning • Optimal expansion planning • Renewable integration • Reliability analysis • Renewable integration • Cost vs. risk tradeoff resource analysis • Battery storage optimization • Financial analysis

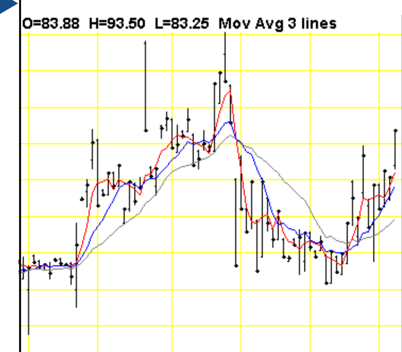
Weather → Renewables/Load → Price Simulations

Weather

Renewables

Load

Gas



Electric

Price

Ascend Analytics

Weather – Load – Delivery – Price Paradigm

Weather

- Weather is the underlying covariate input
- Key benefit is the most appropriate range of future states will be simulated based on historical observations.

Load

- Load is driven primarily by weather
- Key benefit is analysis of high and low temperatures produce more accurate energy expectations, and hourly demand

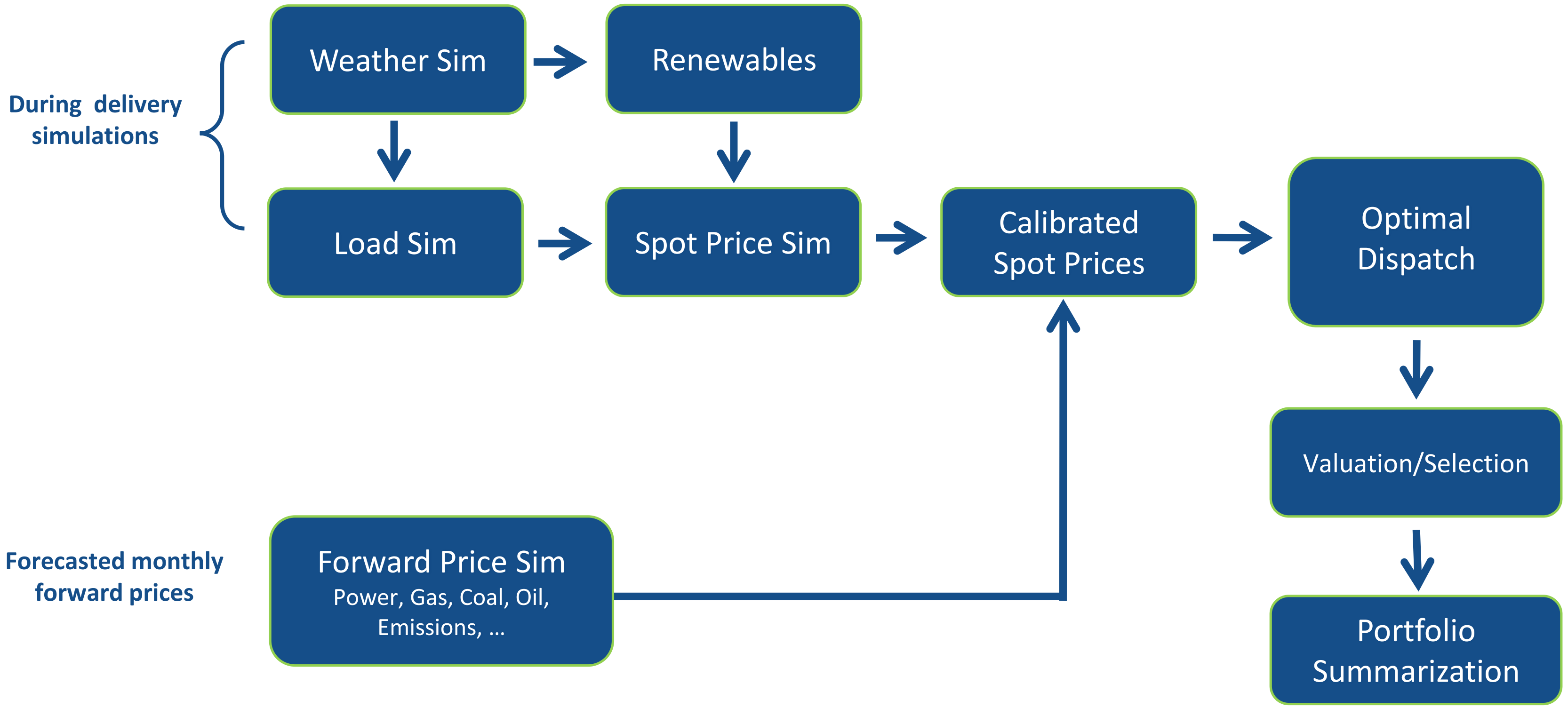
Delivery

- Electricity price is predominantly driven by load
- Key benefit of utilizing multiple variables is they better reflect the factors of economic risks (fuel price, transmission, regulations, etc.).

PowerSimm Modeling Framework

Unified simulation framework reflecting joint financial and physical uncertainty

- Rigorous validation
- Capture of critical causal effects



PowerSimm Modeling Framework

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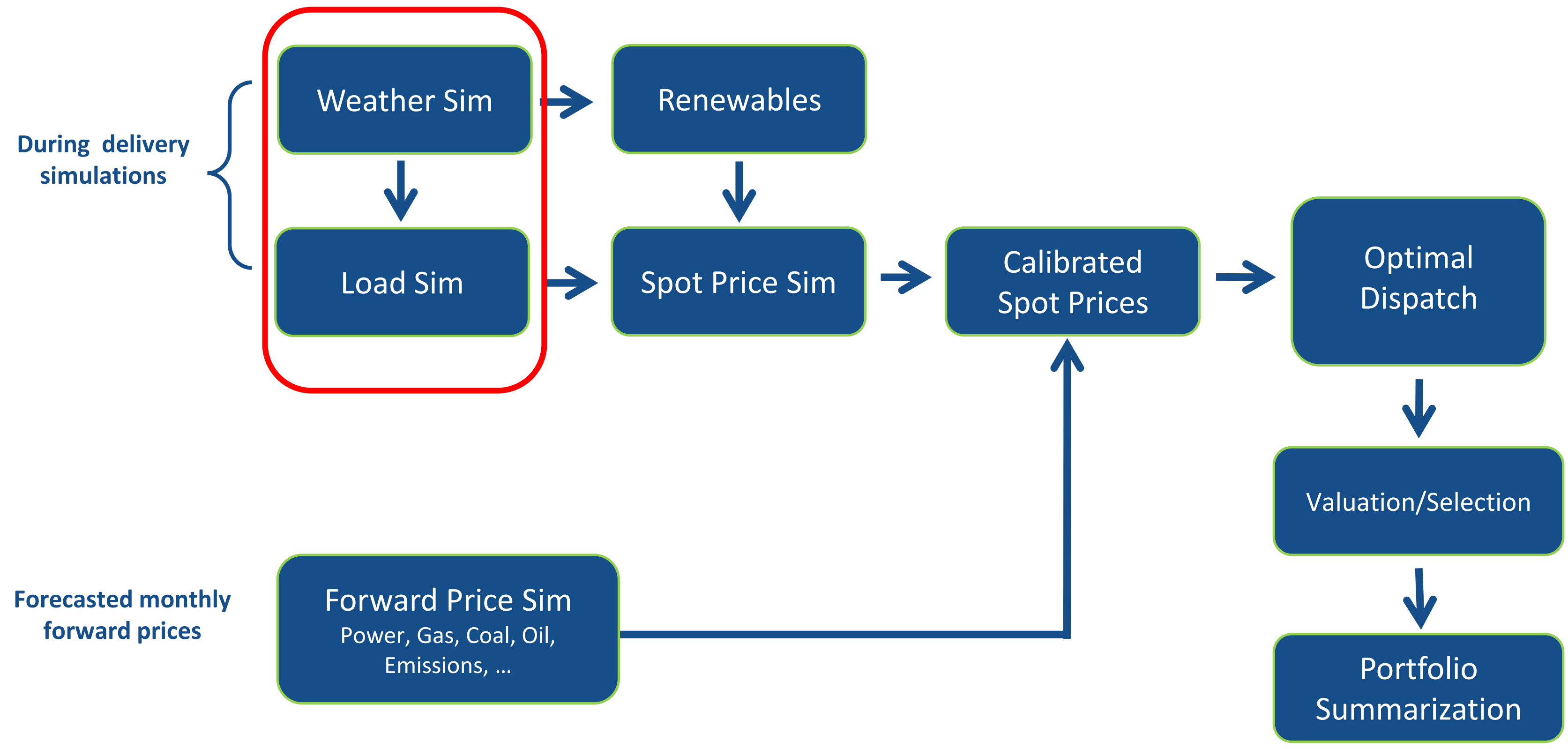
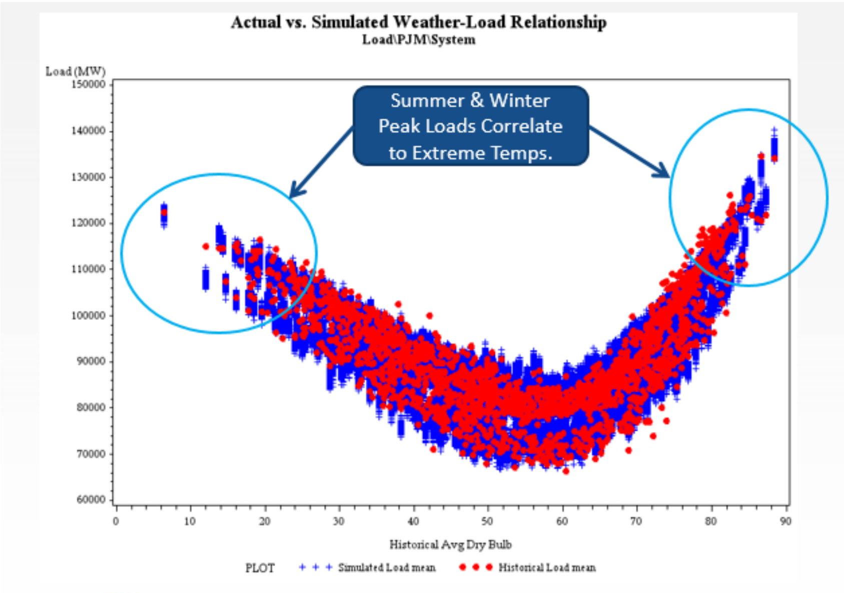
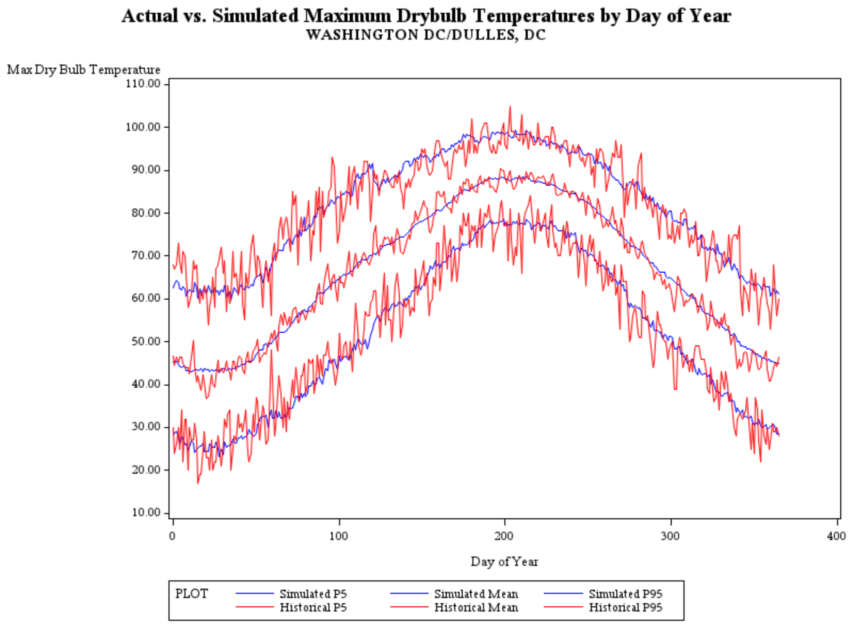


Preserving Relationship and Dependency



Maintaining Relationships

- Incorporating weather into the load model maintains integrity in the weather – load relationship
- Simulations nicely smooth out "bumps" of historical weather record
- Simulations provide for new extreme values to exceed historic record



Validating Relationship

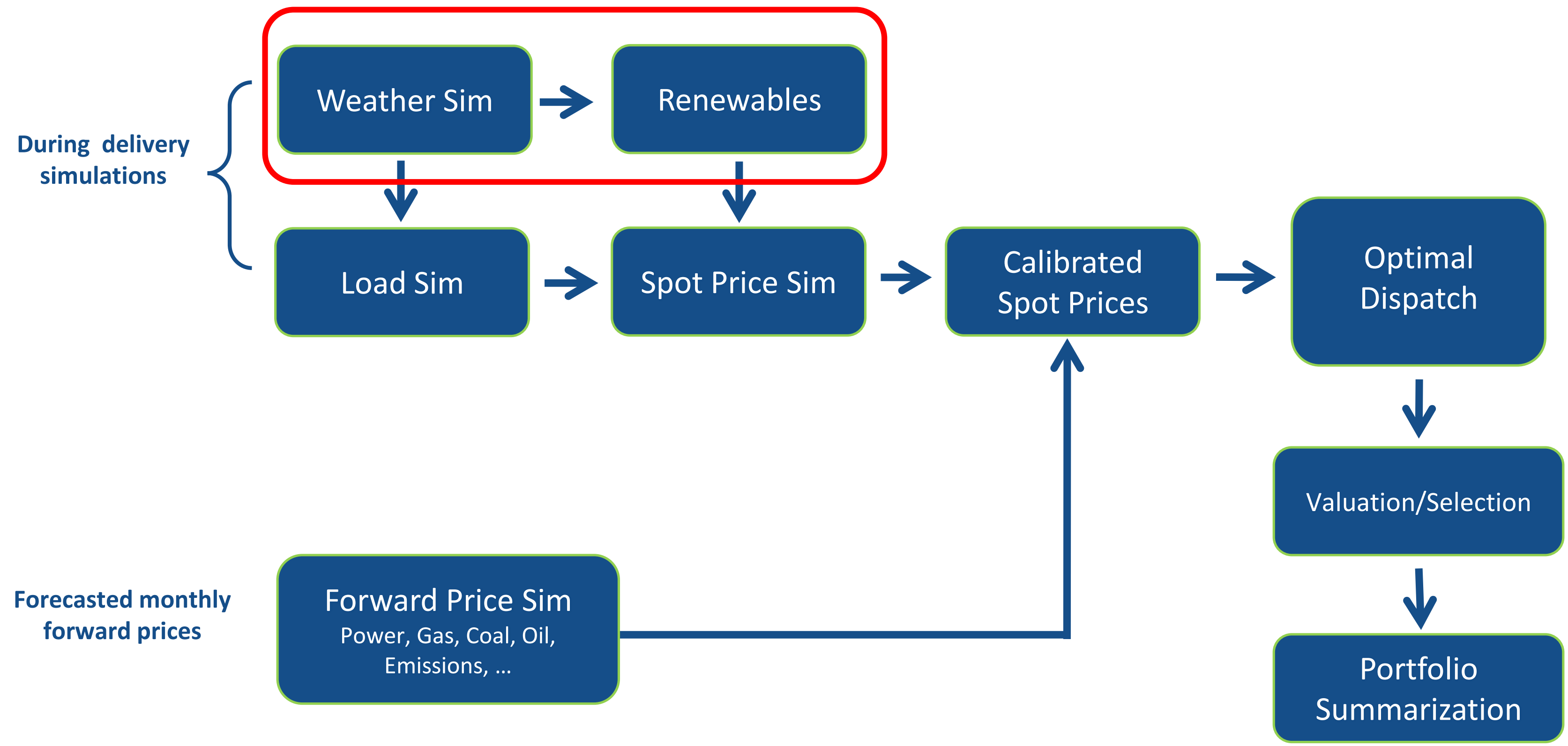
- Validate by capturing the weather – load relationship in the historical period and simulated back-cast
- The structural state space modeling captures the changes in shape with changes in load

Ascend Analytics

PowerSimm Modeling Framework

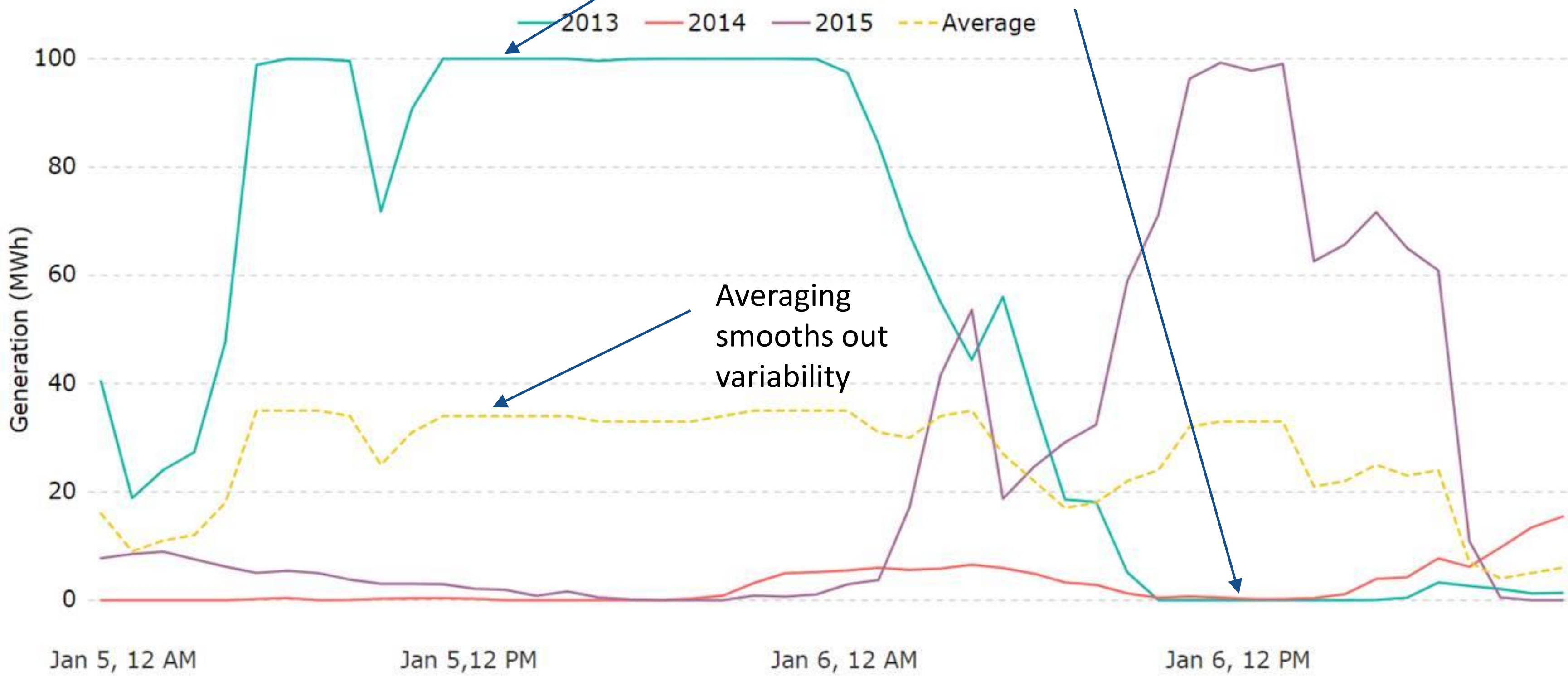
Unified simulation framework reflecting joint financial and physical uncertainty

- Rigorous validation
- Capture of critical causal effects



Why You Can't Just Average Renewables: Wind in January

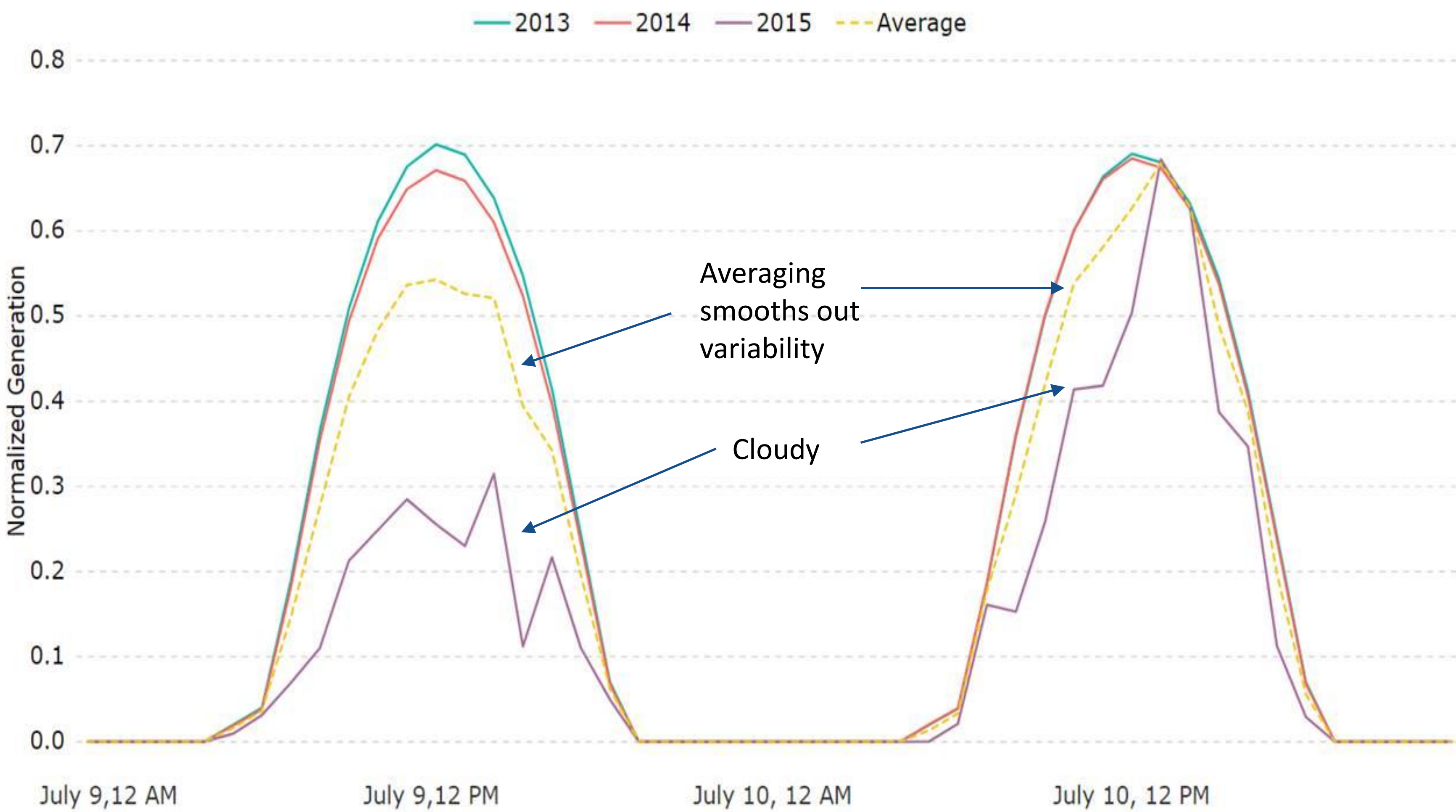
Wind tends to blow hard or not at all



Averaging smooths out variability

Ascend Analytics

Why You Can’t Just Average Renewables: Solar in July

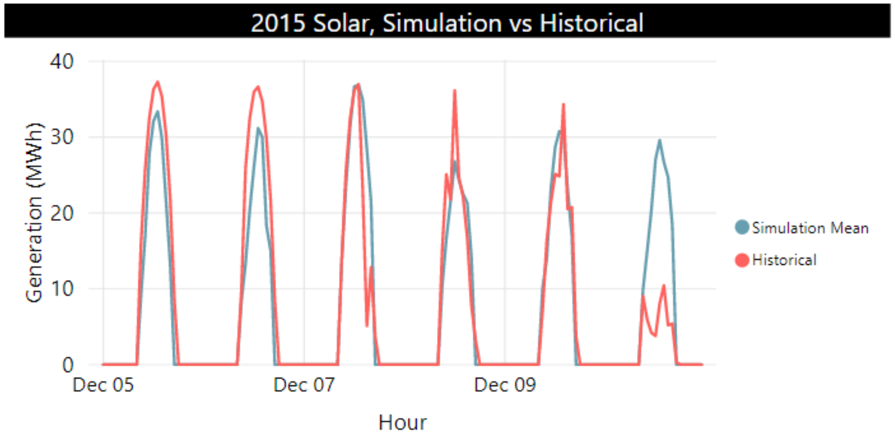


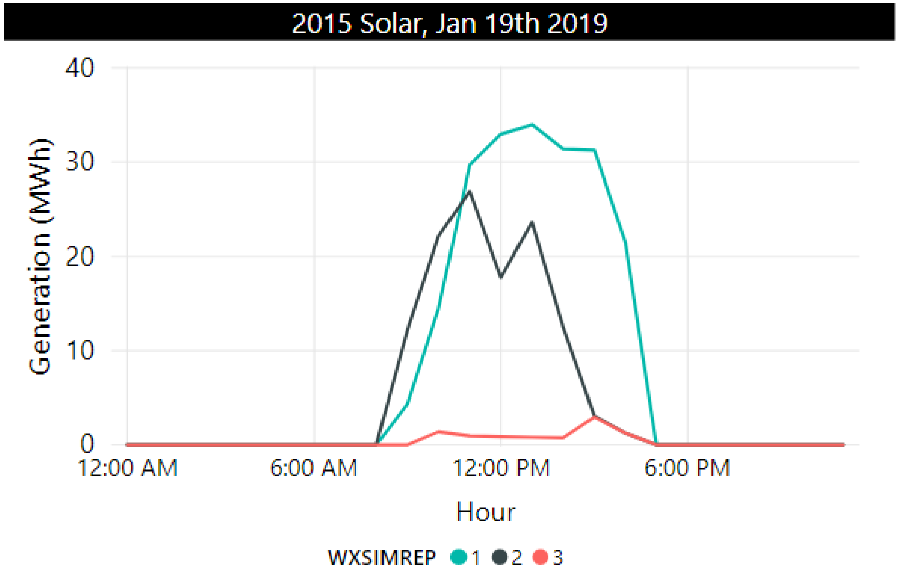
Ascend Analytics

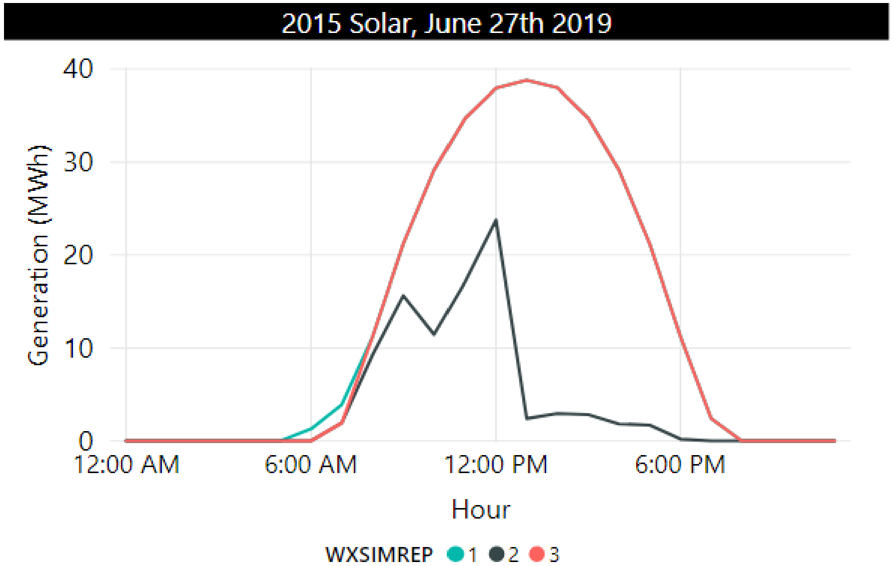
Renewables - Solar

Simulated vs Historical :

- Accurately capturing solar's behavior in summer and winter months by modeling expected peaks in conjugation with nameplate capacities
- Capturing volatility in generation with periods of no generation in winter months and lower maximum generation in winters compared to higher generation in summers



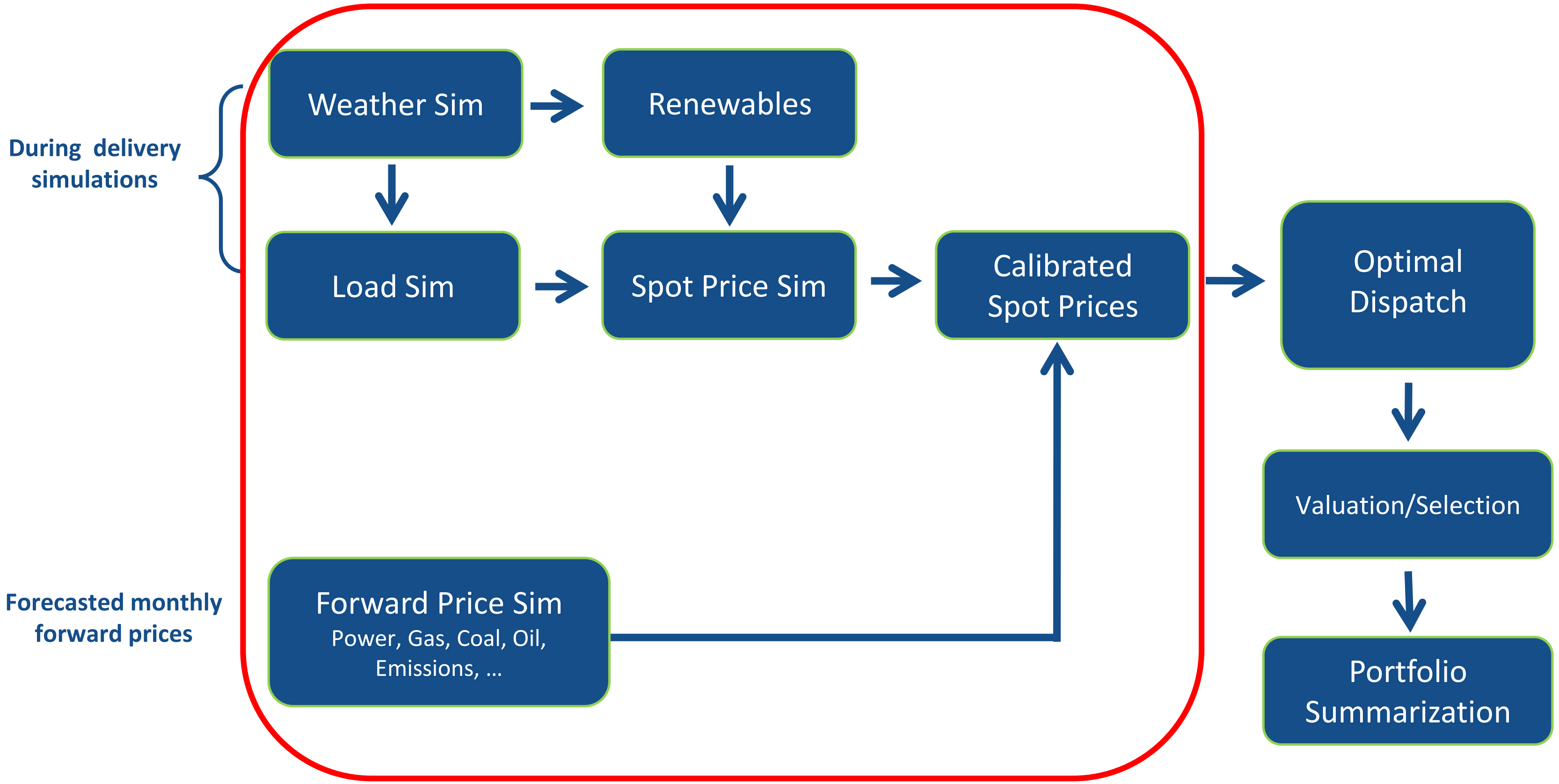




PowerSimm Modeling Framework

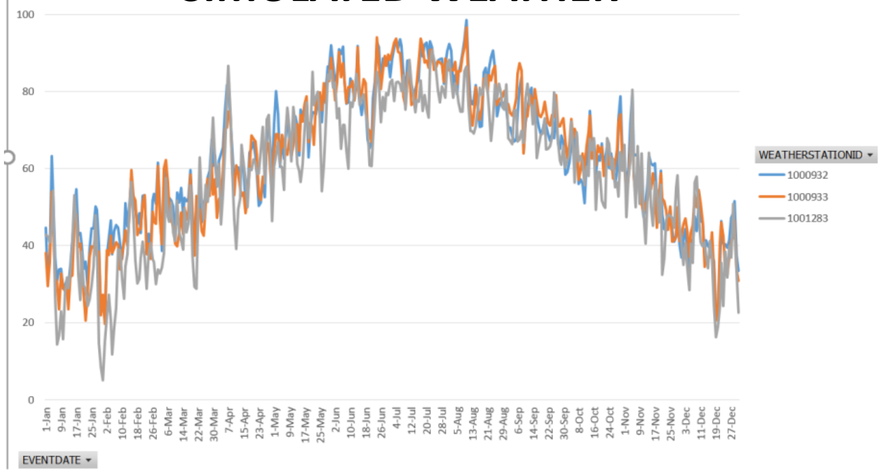
Unified simulation framework reflecting joint financial and physical uncertainty

- Rigorous validation
- Capture of critical causal effects

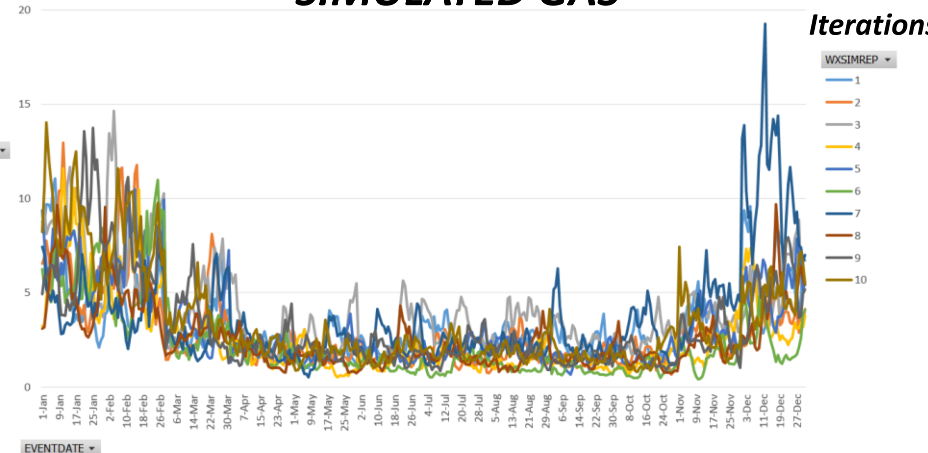


Example: Simulated Temperature, Load, Gas and Power Prices

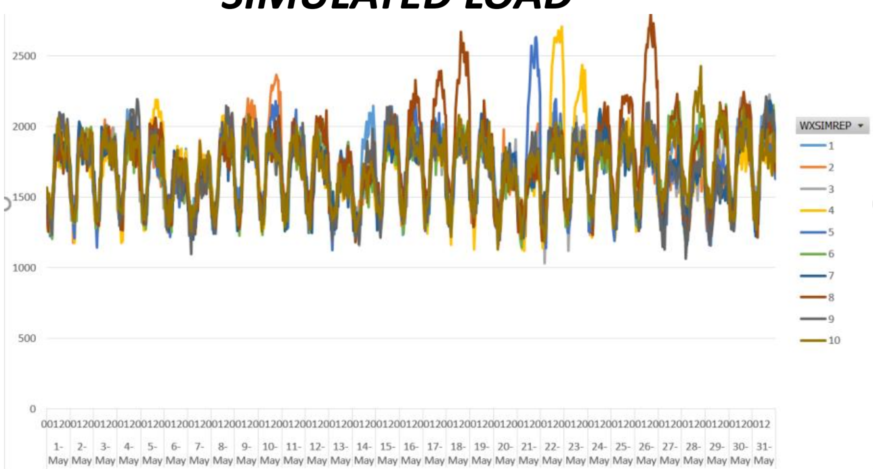
SIMULATED WEATHER



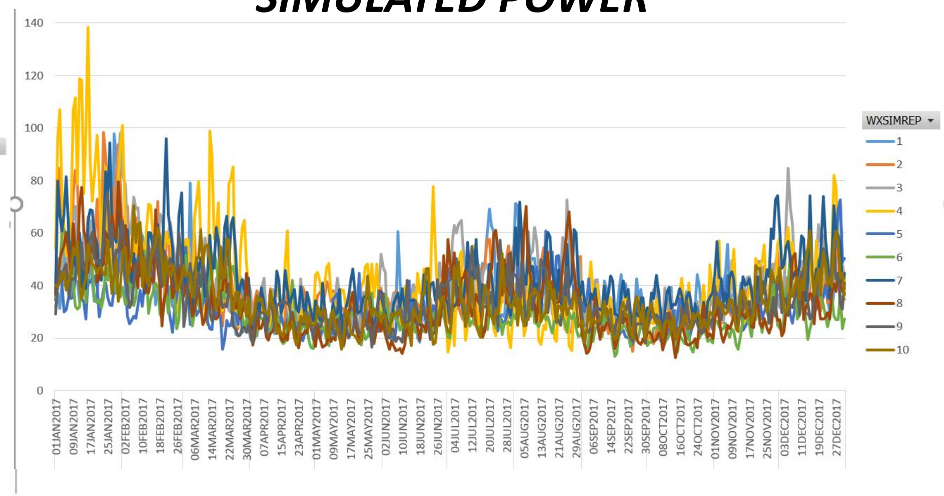
SIMULATED GAS



SIMULATED LOAD



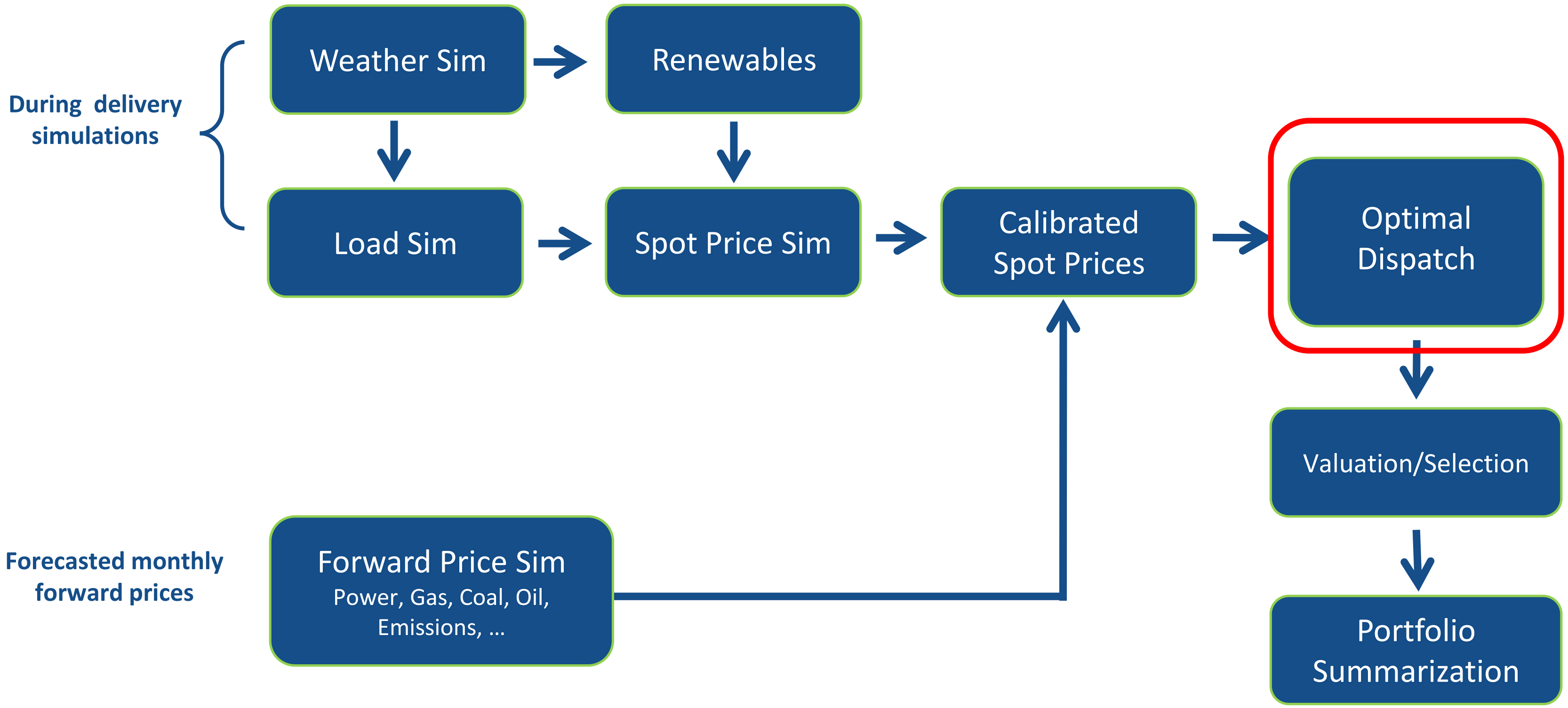
SIMULATED POWER



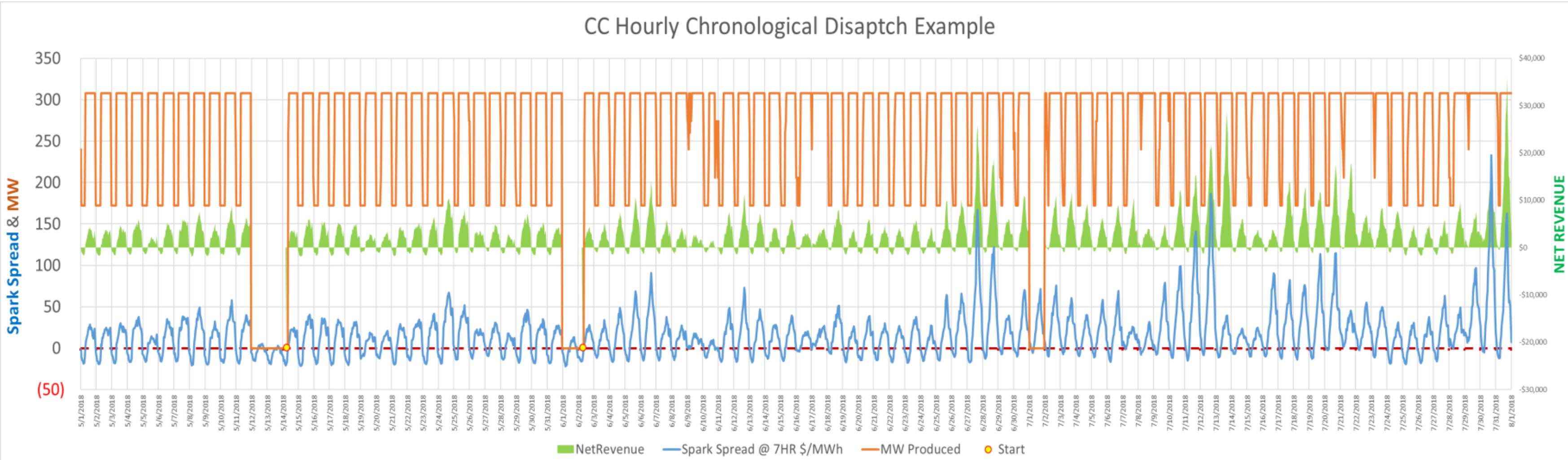
PowerSimm Modeling Framework

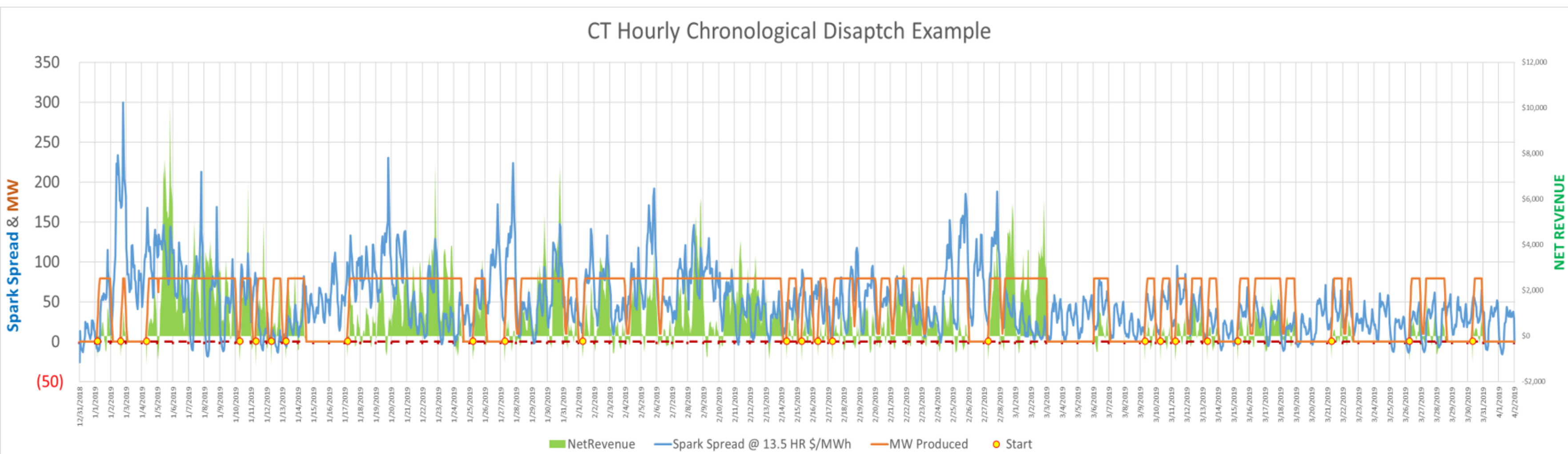
Unified simulation framework reflecting joint financial and physical uncertainty

- Rigorous validation
- Capture of critical causal effects



Thermal Asset Modeling

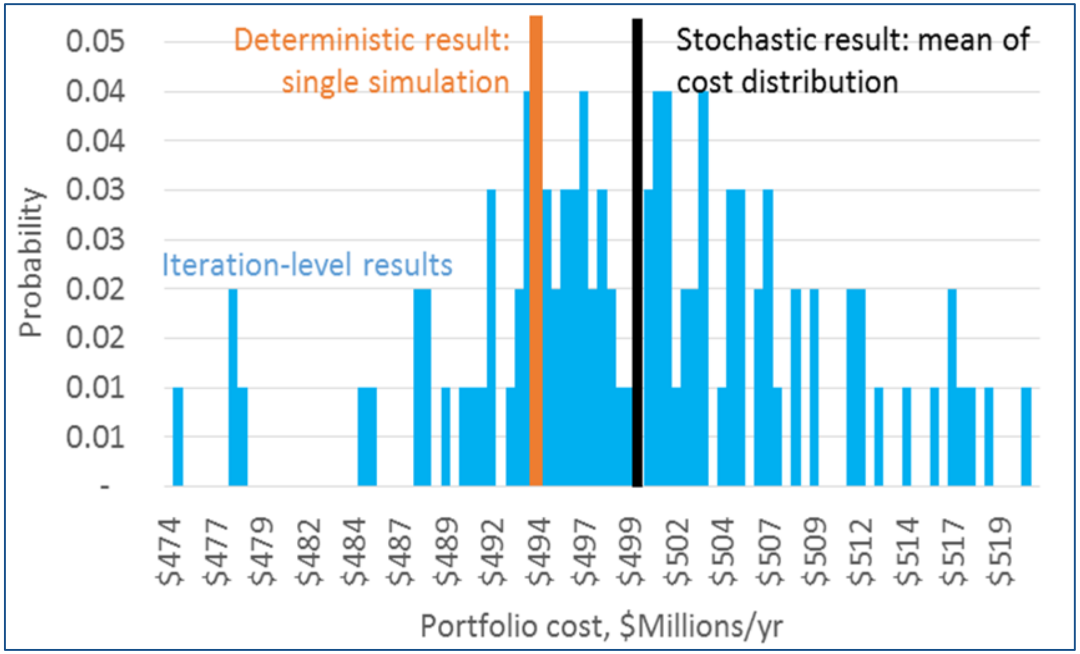




Ascend Analytics

Need for New Tools to Incorporate Uncertainty: Deterministic vs. Stochastic Models

- Deterministic models can bias results with their limited pathways into the future.
  - Deterministic modeling misses critical scenarios, producing inconsistent values.
  - The likelihood of deterministic results actually occurring are not understood.
  - Simulated weather captures actual operations of renewables and load, relative to normalized weather utilized in deterministic models
- What's the impact of unused information
  - Inaccurate forecasting
  - Assessing risk becomes difficult

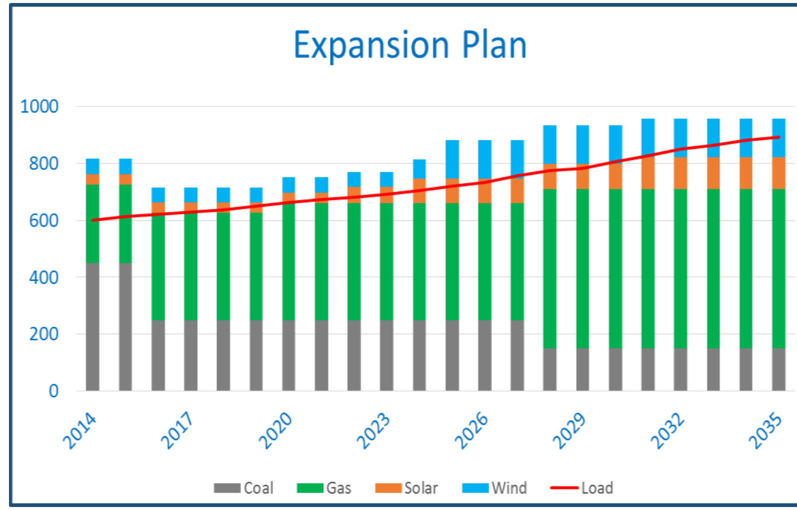


 Ascend Analytics

Planning for future resources, PowerSimm finds the "Best Triathlete"

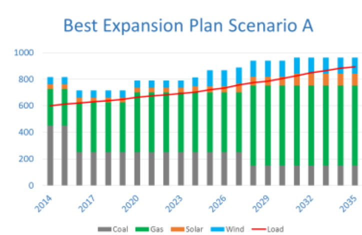
PowerSimm finds the best plan across hundreds of possible future conditions

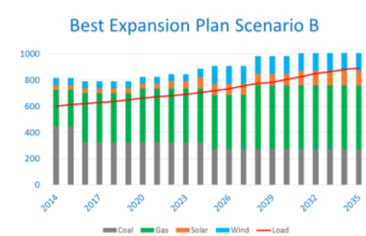
The triathlete is not the best, swimmer, biker, or runner, but the best when combining all three. Likewise, we want to pick a resource plan that performs well in any future condition. This is critical in a highly uncertain future.

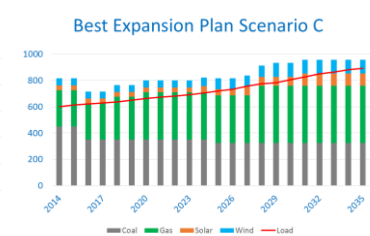


Dave Scott

Best Triathlete







Katie Ledecky

Ryan Hall

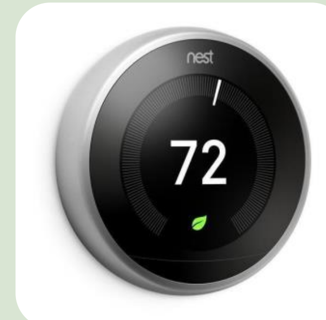
Megan Guanier

REPLACEMENT RESOURCES IN THE 2019 IRP

Patrick Maguire

Director of Resource Planning

REPLACEMENT RESOURCES MODELED



NATURAL GAS

- CCGT
- CT
- Reciprocating Engine/ICE

WIND

- Land-Based Wind

SOLAR

- Utility-Scale
- C&I
- Residential

STORAGE

- Standalone Front-of-meter

DSM/EE

- Measures bundled into tranches by cost and shape

NATURAL GAS

- Combined Cycle (CCGT)
  - F-Class
  - H-Class
- CT
- Reciprocating Engine/ICE
  - Quick start generator sets
  - Higher capital cost
  - More flexible ramp offerings (e.g. off to full load in ~10 minutes)

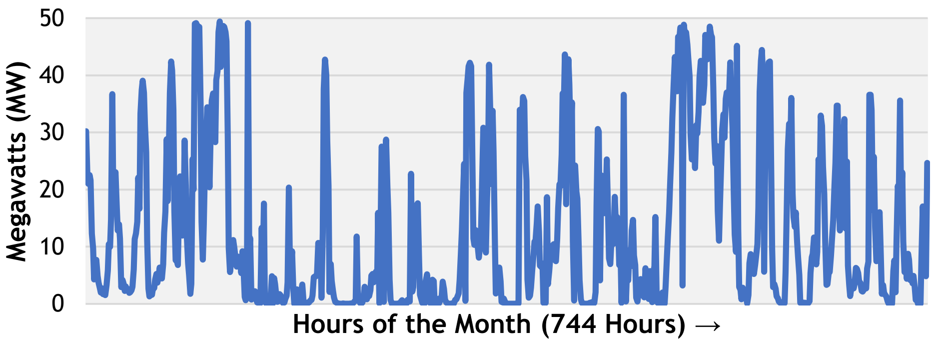
NATURAL GAS
Mature technologies with more certainty around operational parameters and capital costs

WIND

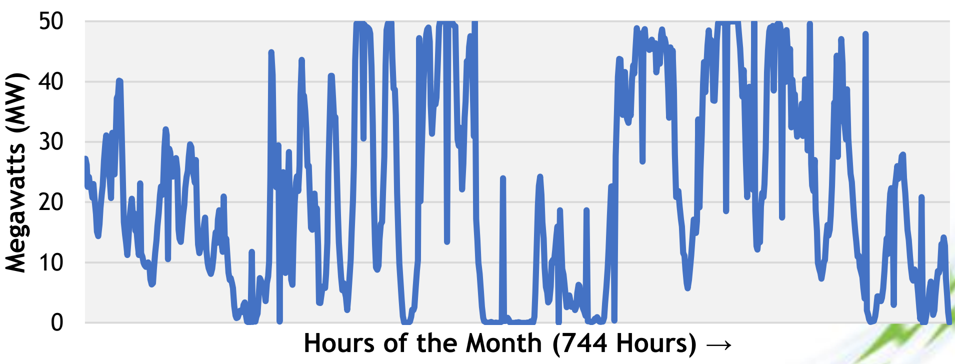
Building Profiles and Capacity Factors

- Wind profiles sourced from a combination of internal data sources (IPL contracted wind projects) and external resources
- NREL Wind Toolkit* provides access to simulated wind profiles at different locations
- Simulated profiles from NREL scaled to IPL's generic wind project size in the PowerSimm model
- Historical hourly simulated production entered in PowerSimm along with monthly forecasted energy

Hypothetical 50 MW Wind Farm in Indiana
JULY Hourly Profile



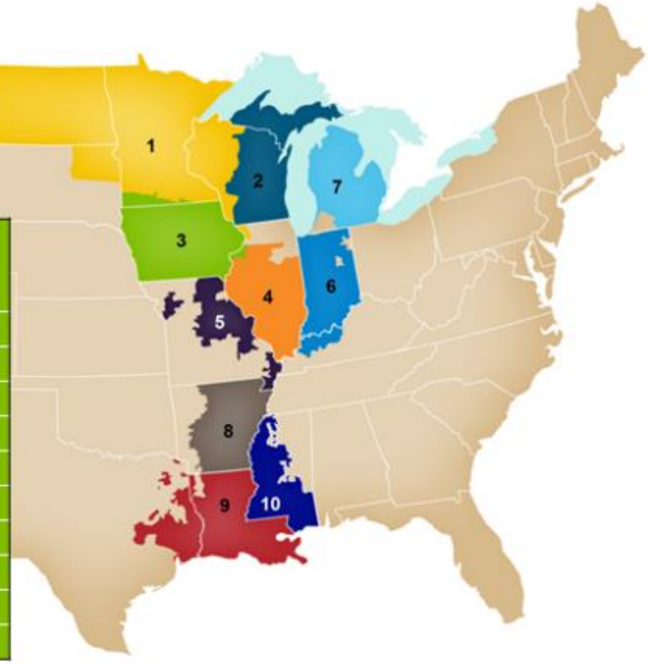
Hypothetical 50 MW Wind Farm in Indiana
JANUARY Hourly Profile



* NREL Wind Toolkit: https://www.nrel.gov/grid/wind-toolkit.html

WIND (CONT'D)

Wind Capacity Credit



Local Resource Zone	Local Balancing Authorities
1	DPC, GRE, MDU, MP, NSP, OTP, SMP
2	ALTE, MGE, MIUP, UPPC, WEC, WPS
3	ALTW, MEC, MPW
4	AMIL, CWLP, SIPC
5	AMMO, CWLD
6	BREC, CIN, HE, IPL, NIPSCO, SIGE
7	CONS, DECO
8	EAI
9	CLEC, EES, LAFA, LAGN, LEPA
10	EMBA, SME

2019										
Metric	MISO	Zone 1	Zone 2	Zone 3	Zone 4 and Zone 5	Zone 6	Zone 7	Zone 8	Zone 9	Zone 10
Registered Max (MW)	18,210	5,080	734	9,488	763	282	1,863	0	0	0
UCAP (MW)	2,855	891	114	1,438	92	22	298	0	0	0
ELCC %	15.7%	17.5%	15.6%	15.2%	12.1%	7.8%	16.0%	0.0%	0.0%	0.0%
Wind CPNode Count	215	74	11	91	9	4	26	0	0	0

Figure 1-1: MISO Local Resource Zones (LRZs) and Distribution of Wind Capacity

Capacity credit for new Indiana wind will be modeled at 7.8% and held constant through study period

Sourced from MISO's December 2018 Wind & Solar Capacity Credit Report*

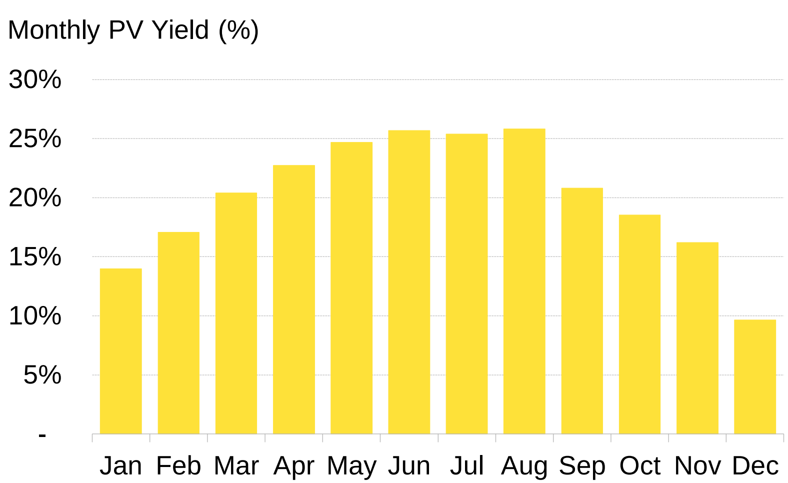
* MISO Wind & Solar Capacity Credit Report, December 2018 (PDF):
https://cdn.misoenergy.org/2019%20Wind%20and%20Solar%20Capacity%20Credit%20Report303063.pdf

SOLAR

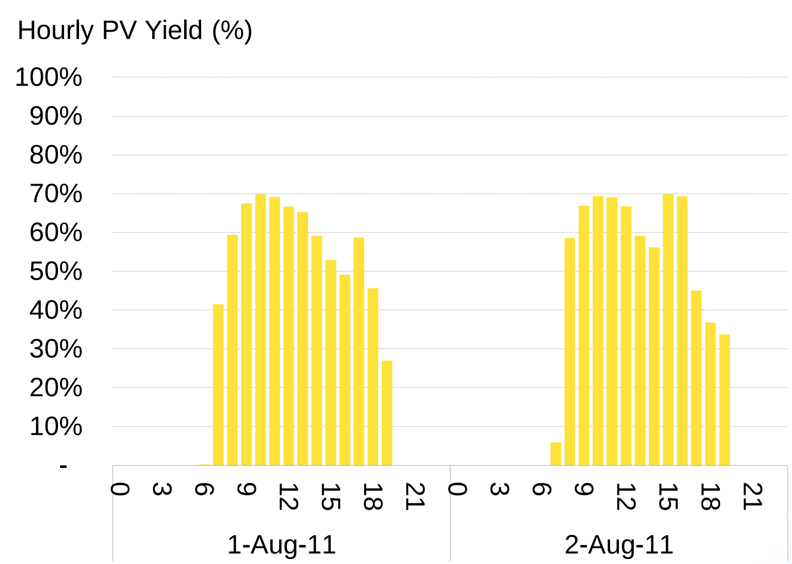
Building Profiles and Capacity Factors

- IPL's 96 MW of solar provides a robust source of hourly profile data
- Profiles also sourced from Bloomberg New Energy Finance (BNEF) Solar Capacity Factor Tool (SCFT 1.0.5)

Hypothetical Single-Axis Tracking Solar Project in IPL's Service Territory



Source: BloombergNEF & PVGIS.



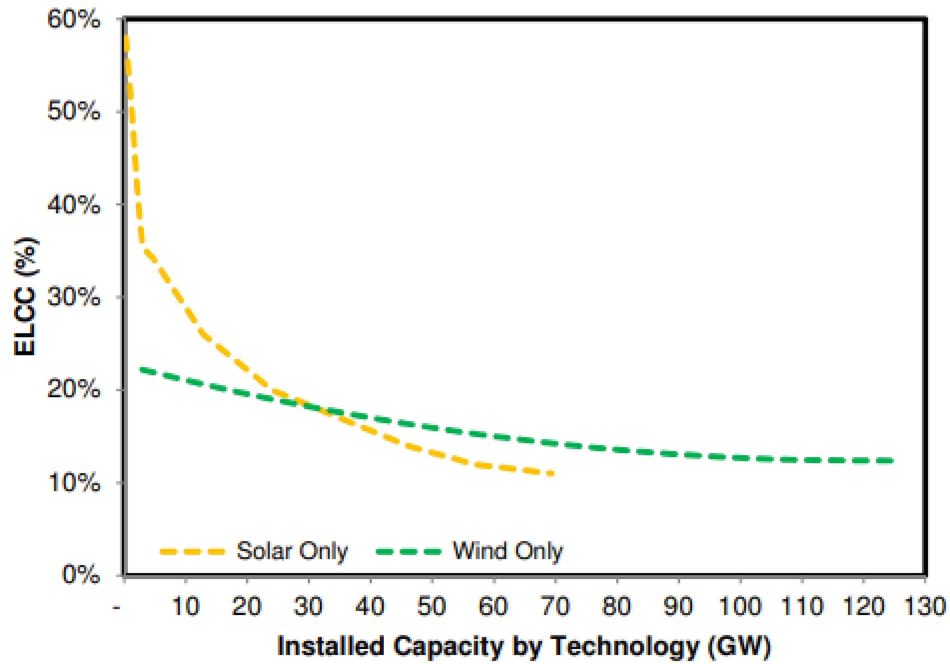
Source: BloombergNEF & PVGIS.

SOLAR (CONT'D)

Solar Capacity Credit

- Currently new solar projects in MISO receive 50% capacity credit
- Capacity credit expected to decline as more solar added to the system due to shift in net peak load
- IPL will align supply fundamentals from commodity forecast with information from MISO to calculate annual solar ELCC %
- **Capacity credit will start at 50% and decline over time**
- Annual capacity percentages to be provided and discussed at the March 13th meeting

Wind and Solar ELCC as a function of installed capacity*



* Source: MISO Renewable Integration Impact Assessment (RIIA) Assumptions Document, Version 6
https://cdn.misoenergy.org/RIIA%20Assumptions%20Doc_v6301579.pdf

STORAGE

- 4-Hour battery storage considered for modeling
- MISO requires a 4-hour test for capacity accreditation
- Modeled as energy arbitrage and capacity resources
  - No sub-hourly, DA/RT, or ancillary services modeled this IRP
  - Battery modeling still evolving along with ISO market rules

4-Hour Storage
Example: • 20 MW, 80 MWh battery • Can discharge 20 MW for 4 hours • UCAP = 20 MW * (1 – xEFORd%)

BREAK

DSM/EE AND LOAD FORECAST OVERVIEW

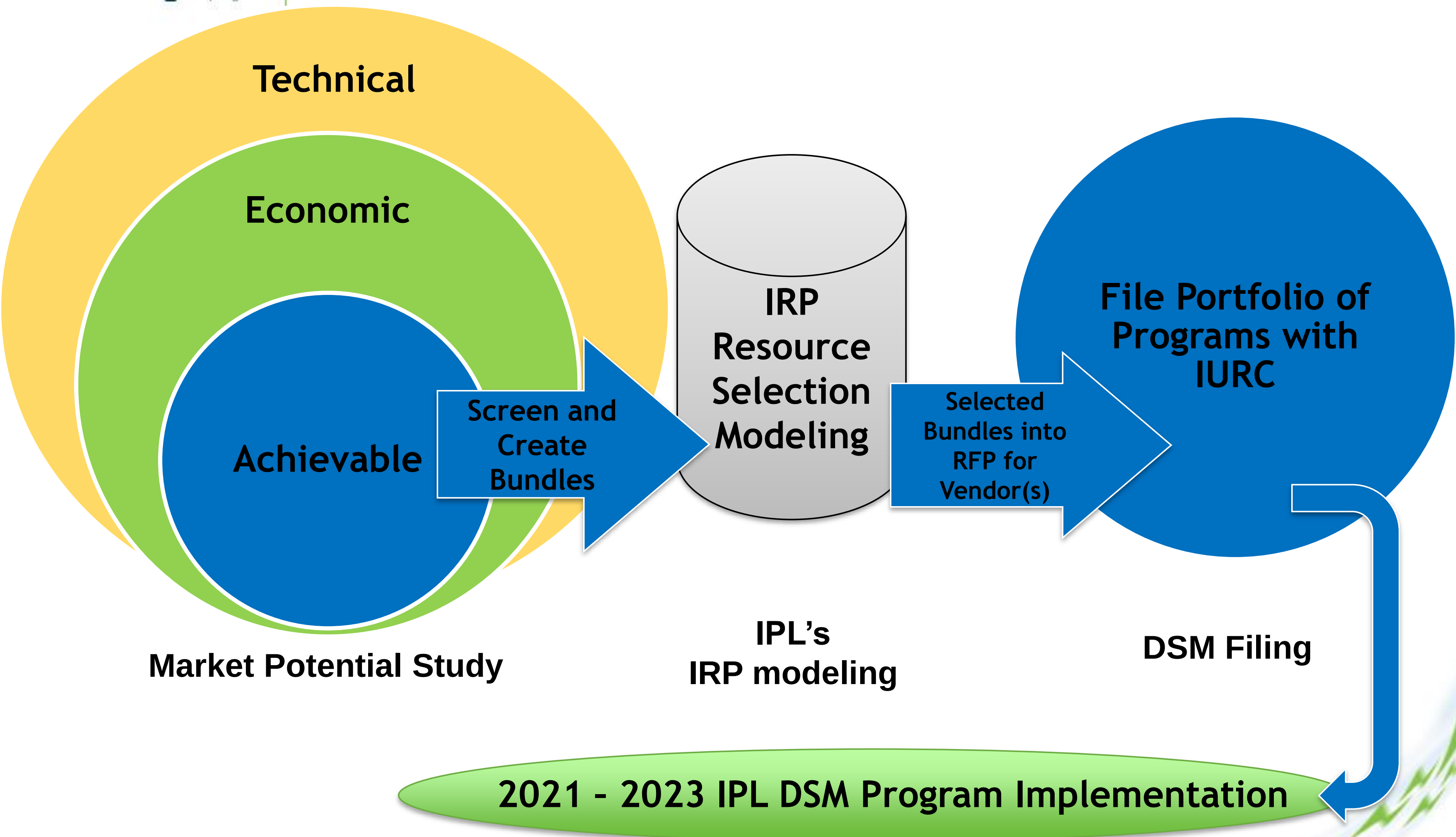
Erik Miller

Senior Research Analyst

DSM UPDATE

- Market Potential Study (MPS)
  - DSM & the IRP
  - DSM Bundles
  - MPS Overview
  - End-use Analysis

DSM PROCESS & THE IRP



DSM BUNDLES

Example of Bundles from the IPL 2016 IRP:

Near-term DSM "blocks" developed for 2018 - 2020 (Base Case Selections)			
	Levelized Utility Cost per MWh		
Sector and Technology	(up to $30/MWh)	($30-60/MWh)	($60+ /MWh)
EE Residential HVAC	Selected	Not Selected	Not Selected
EE Residential Lighting	Selected	N/A	N/A
EE Residential Other	Selected	Not Selected	Not Selected
EE C&I HVAC	Selected	Not Selected	Not Selected
EE C&I Lighting	Selected	Not Selected	Not Selected
EE C&I Other	Selected	Not Selected	Not Selected
EE C&I Process	Not Selected	Not Selected	N/A
EE Residential Behavioral	Not Selected		
DR Water Heating DLC	Not Selected		
DR Smart Thermostats	Not Selected		
DR Emerging Tech	Not Selected		
DR Curtail Agreements	Not Selected		
DR Battery Storage	Not Selected		
DR Air Conditioning Load Mgmt	Not Selected		

*N/A indicates that a bundle was not needed; all measures fell within lower cost bundles.

MARKET POTENTIAL STUDY OVERVIEW

- IPL working with GDS Associates to complete the Market Potential Study
- MPS will cover IRP years: 2020 – 2039
- Per the Settlement Agreement in IPL's 2018 – 2020 DSM Order (44945) – MPS will also include a market refresh for 2020
    - Results of the refresh will be considered for adoption in 2020; not be modeled as a resource in the IRP

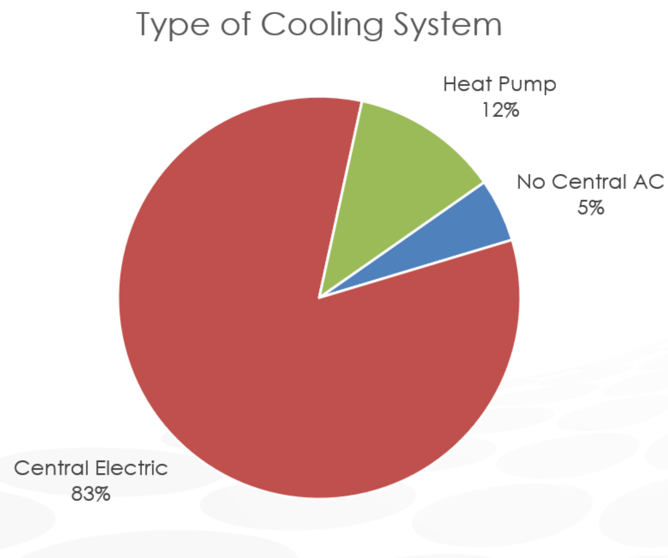
MARKET POTENTIAL STUDY PROCESS

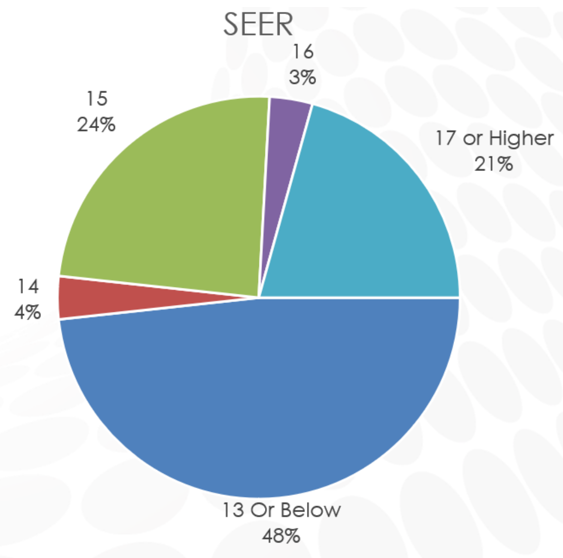
- Step 1: End Use Analysis & Market Characterization by sector; Current snapshot of IPL's Market
- Step 2: Load Forecast – Baseline projection of energy consumption absent future programs by sector and by end use; estimate saturations and efficiencies of technologies
- Step 3: Define energy efficiency and demand response measures to consider
- Step 4: Define Technical & Economic Potentials
- Step 5: Develop and apply adoption rates; Determine Achievable Potential
- Step 6: Develop inputs for the IRP model

END USE ANALYSIS OVERVIEW

- The End Use Analysis establishes the market baseline which informs the load forecast used in the MPS
  - Characterizes the end uses within each sector
  - Establishes the saturation and efficiencies of the end uses
  - Provides a snapshot and starting point for the MPS
- Analysis is performed through surveys and site visits that were completed during the fall of 2018
- In previous MPS, IPL relied on regional EIA data for the end use characterization as opposed to surveys and site visits

End Use Example: Residential Cooling





LOAD FORECASTING UPDATE

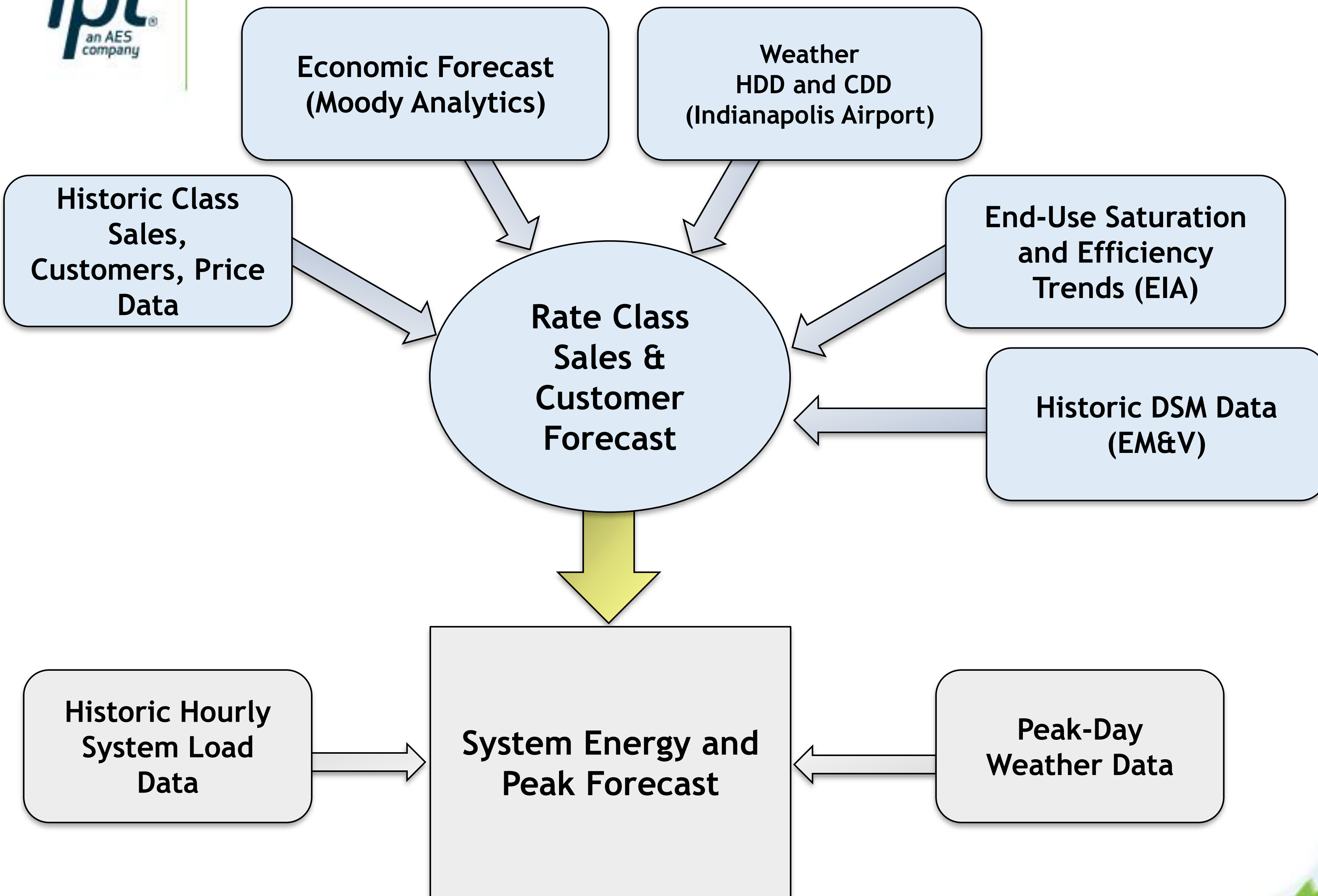
- Load Forecast
  - Methodology & Approach
  - Model Framework

- MPS & Load Forecast Schedule

METHODS FOR LOAD FORECASTING

- Top-Down
  - Trend analysis
  - Time Series
- Bottom-Up
  - Survey-based
  - End-use
- **IPL Methodology: Hybrid**
  - Itron's Statistically-adjusted end-use (SAE) model

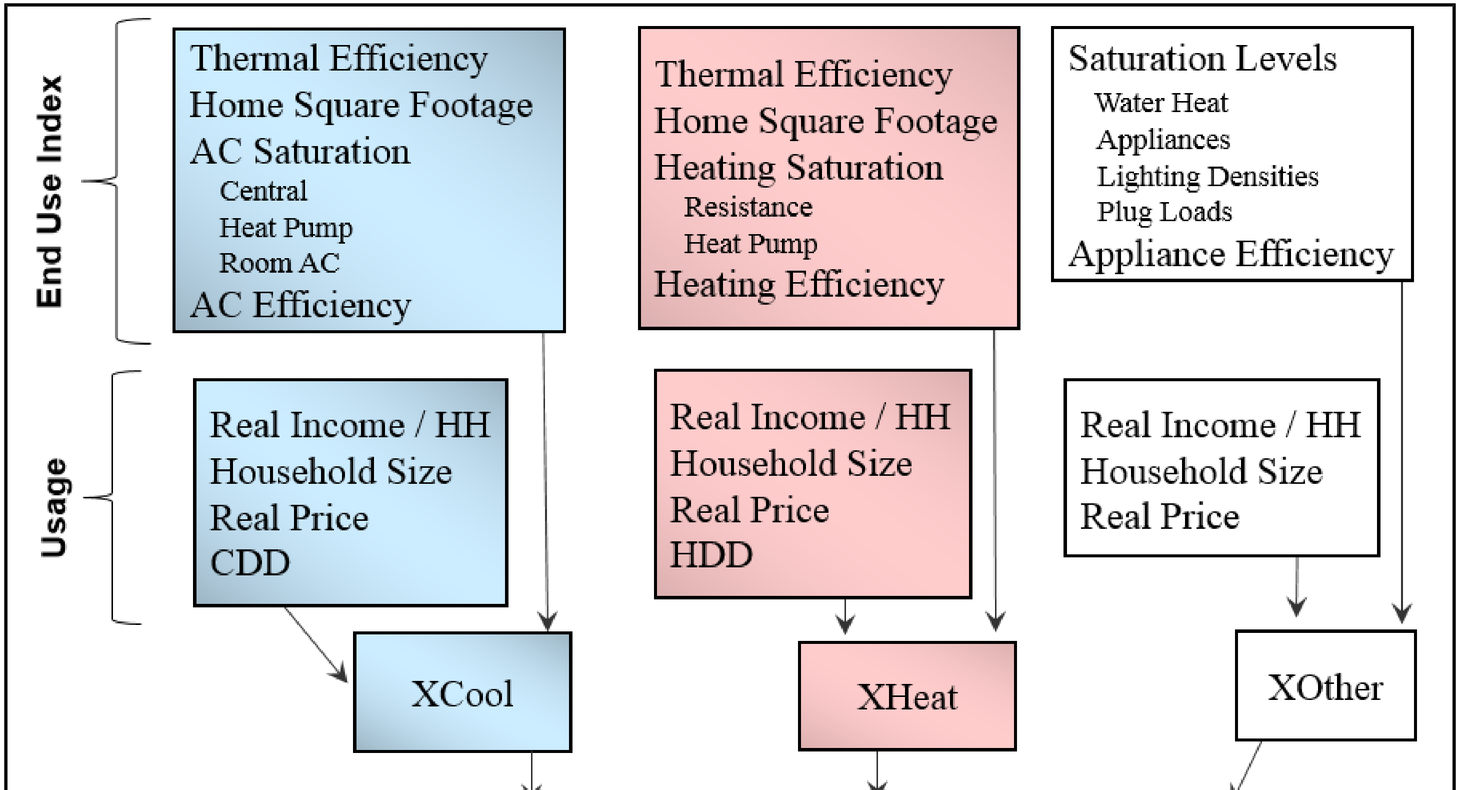
FORECAST MODELING FRAMEWORK



FORECAST MODELS

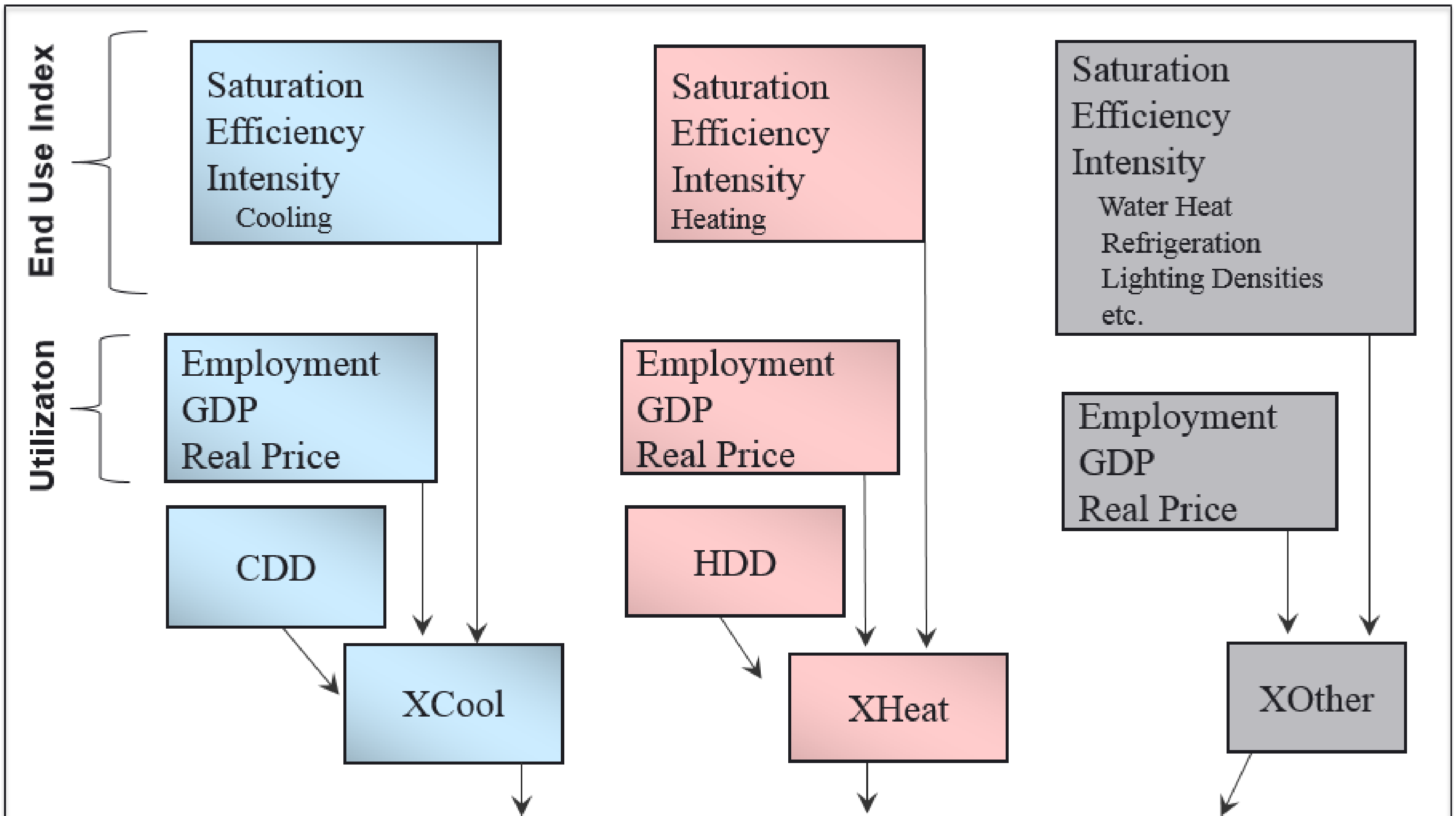
- Forecasts are based on monthly regression models using historical sales and customer data
- Sales Models
  - Residential and commercial models estimated using a blended end-use/econometric modeling framework
  - Industrial sales estimated with a generalized econometric model
  - Small rate classes such as process heating, security lighting, and street lighting are estimated using simple trend and seasonal models
- Demand Model
  - Monthly system peak model based on heating, cooling, and base-use energy requirements derived from the sales forecast models

RESIDENTIAL MODEL FRAMEWORK



$$AvgUse_m = a + b_c \times XCool_m + b_h \times XHeat_m + b_o \times XOther_m + e_m$$

COMMERCIAL MODEL FRAMEWORK



$$Sales_m = a + b_c \times XCool_m + b_h \times XHeat_m + b_o \times XOther_m + e_m$$

INDUSTRIAL MODEL FRAMEWORK

Industrial sales are estimated with a generalized econometric model

Cooling Degree Days

Manufacturing Employment
Manufacturing Output
Price

$$Sales_m = a + b_{cdd} \times CDD_m + b_{Econ} \times EconVariable_m + e_m$$

DSM AND LOAD FORECAST SUMMARY

- DSM
  - MPS Results will be presented at the March 13th meeting
    - Introduction to bundles
- Load Forecast
  - Base forecast and high/low scenarios will be presented at the March 13th meeting

FINAL Q&A AND NEXT STEPS

Patrick Maguire

Director of Resource Planning

NEXT STEPS

- **Next Meeting: March 13, 2019**
  - IPL Electric Building
  - Register at http://iplpower.com/irp
- Meeting #2 Material:
  - Commodity Forecast Assumptions
  - Capital Cost Assumptions
  - Proposed Scenario and Modeling Framework
  - Detailed Load Forecast (Peak and Energy)
  - Market Potential Study Update

Email questions, comments, or other feedback to ipl.irp@aes.com