[2016 IEAGHG CCS Summer School]

Electricity System Modelling (Generation)

Doug Opseth, Director
Supply Planning and Integration

July 17, 2017

SaskPower
Powering the future®

What we'll talk about today

- Why do we need to plan?
- What are the challenges of planning?
- How do we plan now?
- How will we plan in the future?
- Your questions

SaskPower
Powering the future®

Why do we plan?

- To keep the lights on
- To insure reliability
- To manage risk (both from a supply and financial perspective)

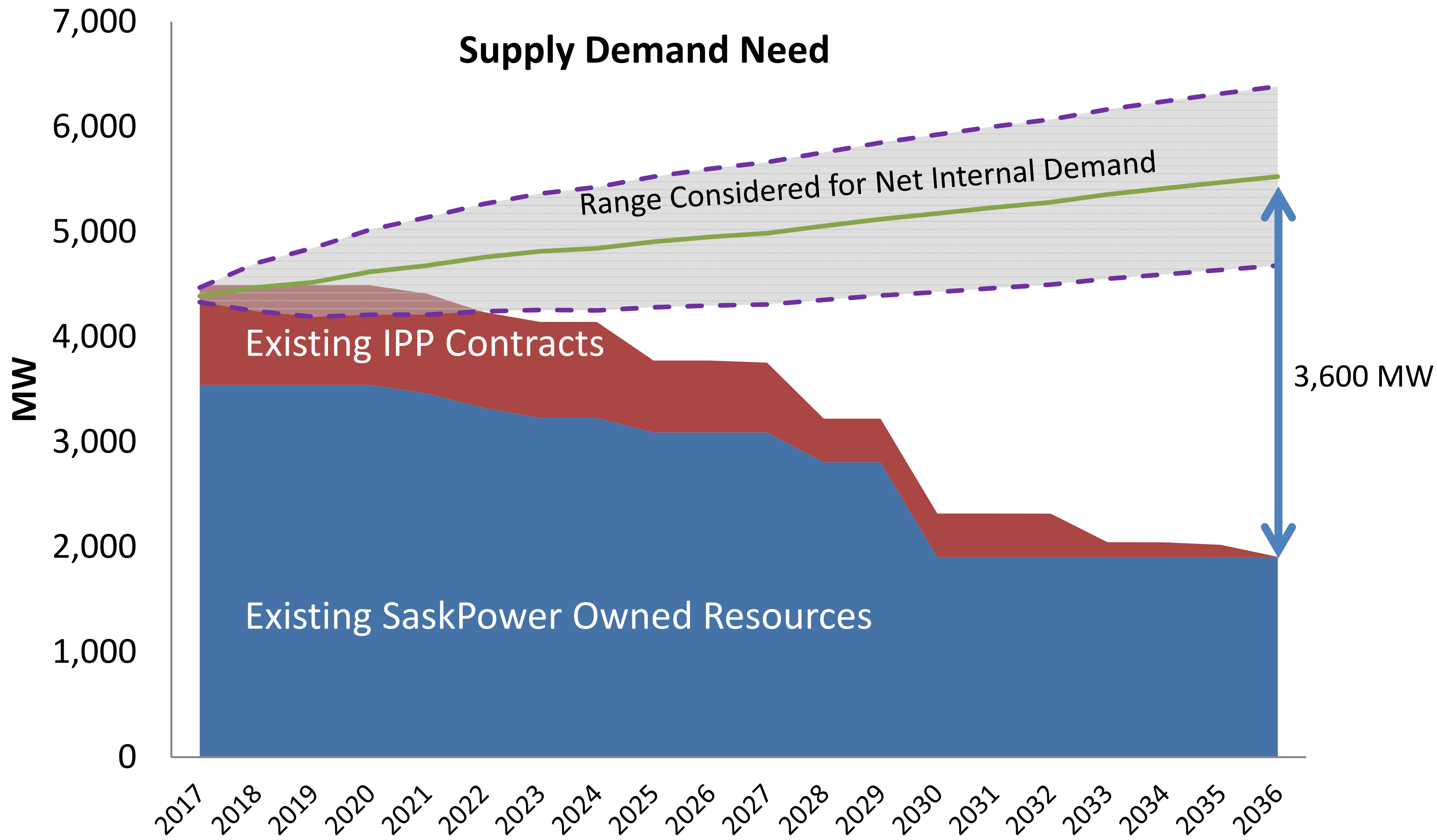
SaskPower
Powering the future®

OUR KEY CHALLENGES

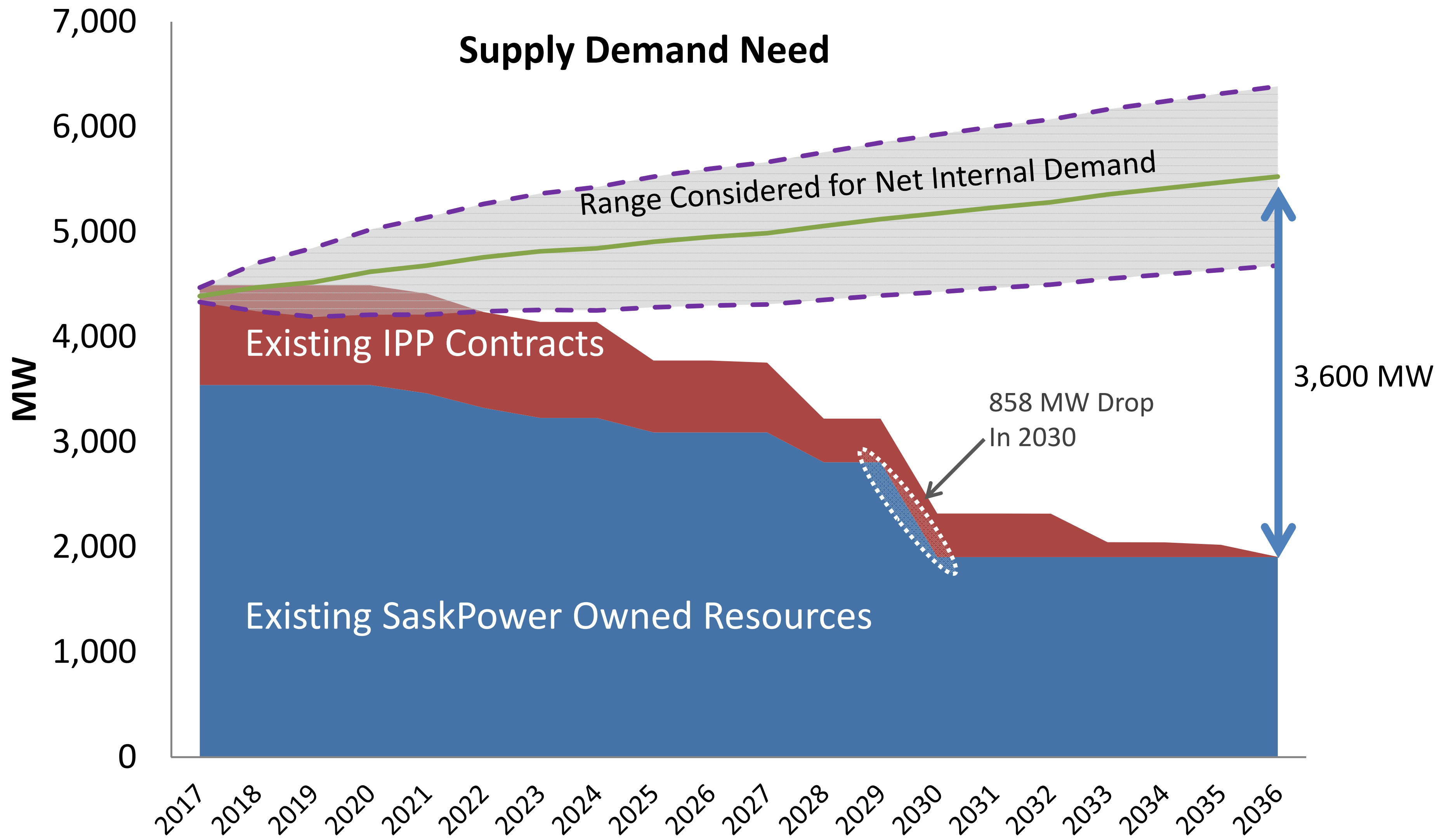
- Growing demand for power in Saskatchewan
- Aging power system/infrastructure
- Regulations eliminate conventional coal (without carbon capture) and will restrict emissions on natural gas going forward
- Integrating more renewable (but intermittent) generation sources
- Managing Rates

SaskPower
Powering the future®

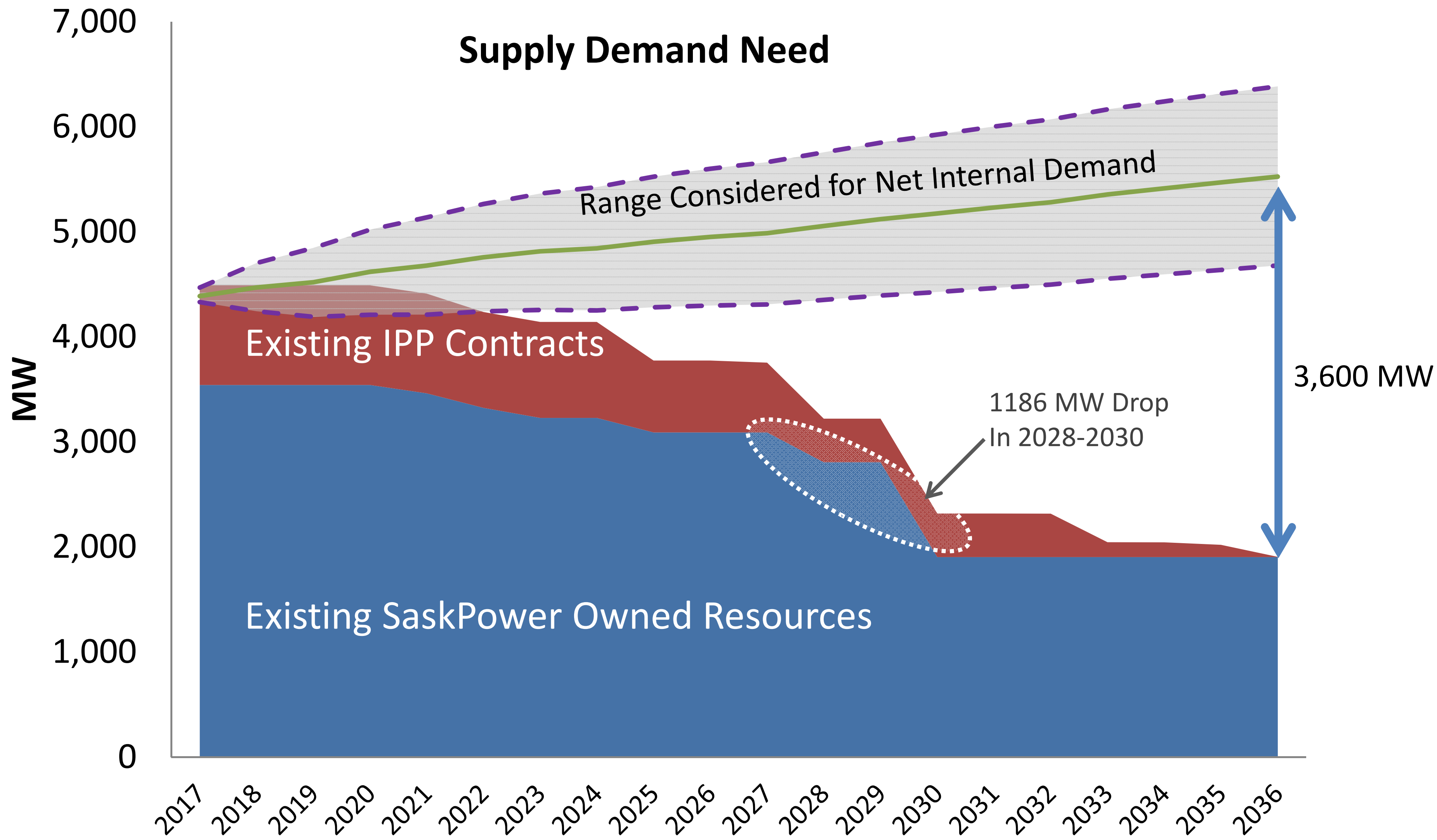
THE CHALLENGE



THE CHALLENGE



THE CHALLENGE



Considerations and criteria

How we "*close the gaps*" is determined by assessing a number of variables, including:

- System reliability and integrity
- Regulatory requirements (e.g. carbon penalties)
- Fuel price and availability
- Technology limitations and system integration
- Levelized cost/MWh
- Diversification (managing risk)
- Public acceptance

SaskPower
Powering the future®

Option	Load Following	First Year Available	*Est. cost range ($/MWh)	Key risks
Demand Side Management	Varies	2017	5-200	- changes in consumer market conditions, behaviour, regulations and codes
Natural gas	Yes	2019	60-85	- price flux; social licence; emissions
CCS	No	2023	110-150	- costs dependent on sale of CO_2; emissions regs;
Hydro (SK)	Yes	2021	125-180	- high capital costs; limited resource
Imports (hydro)	No	2017	100-125	- limited availability; social licence
Nuclear (SMRs)	No	2030	115-160	- high capital costs; new regulatory env. in SK; social licence
Flare gas	No	2018	95-125	- limited resource
Wind	No	2020	70-100	- grid integration estimated at $13/MWh
Solar	No	2018	120-180	- grid integration estimated at $22/MWh
Biomass	No	2018	169-195	- limited resource
Geothermal	No	2020	150-195	- limited resource

*based on 2023 in-service dates (SMRs based on 2030) in 2016 dollars. *Estimated and subject to change.
As of December 2016

Primary System modelling tools Today

- **PROMOD** (**Pro**duction **Mod**elling)
  - o Simulates the operation of the system
- **STRATEGIST**
  - o Long-term planning; helps determine cost and timing of potential scenarios

SaskPower
Powering the future®

What is an Integrated Resource Plan?

A 20-year look ahead that evaluates reliable, cost-effective resource options (supply-side and demand-side) for meeting future electricity demand; updated every 2 to 3 years.

The 2017 IRP strives to accomplish the following:

- **Ensure reliability** for all stakeholders
- **Evaluate all options** fairly and consistently
- **Minimize costs** to all stakeholders
- **Create a flexible plan** that allows for uncertainty
- **Reduce CO2 emissions** from power generation
- The IRP also **aspires to include stakeholders**

SaskPower
Powering the future®

INTEGRATED RESOURCE PLAN

What has been done differently:

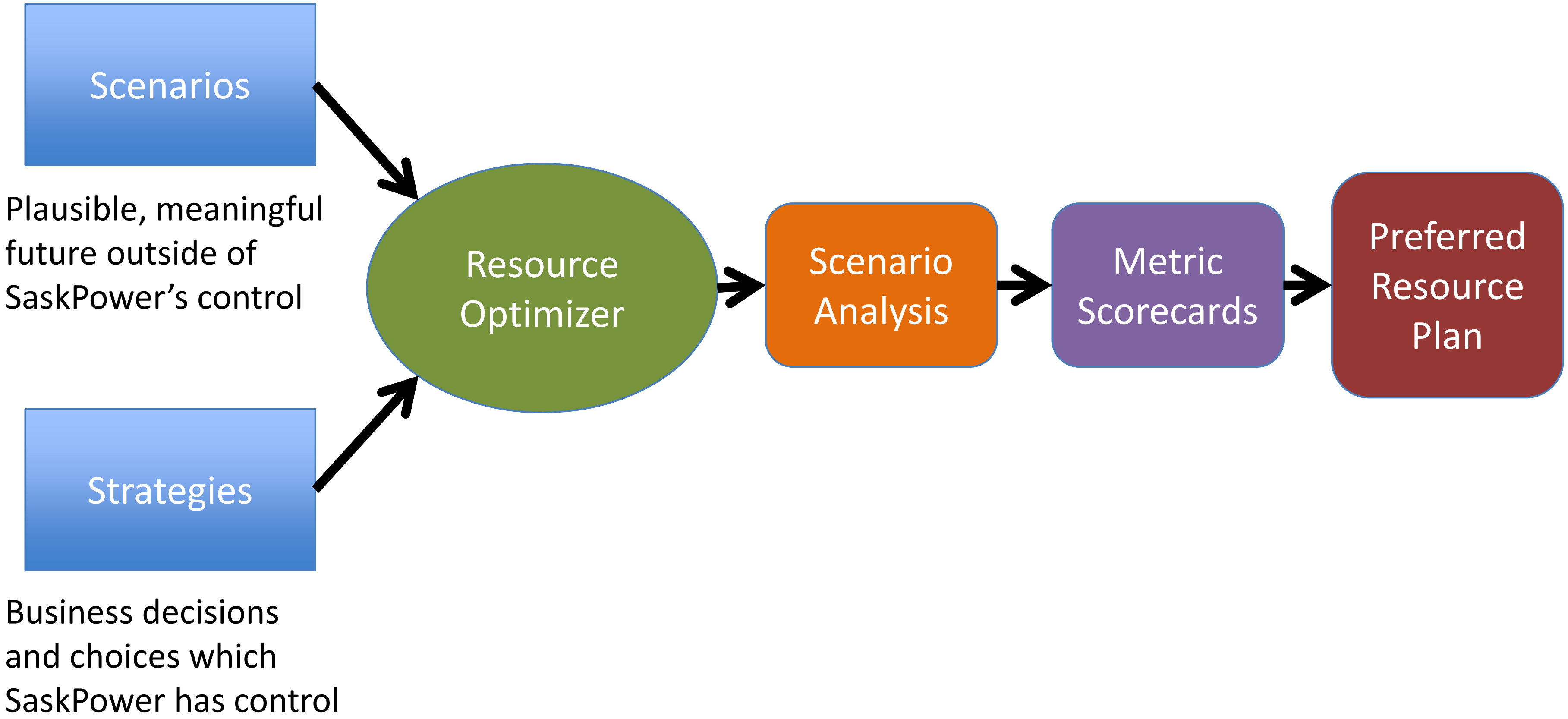
- Utilizes a scenario analysis approach
- Scorecards illustrate trade-offs between resource strategies
- Evaluates Demand Side Management as a resource option
- Incorporates aspects of Generation, Transmission, Distribution planning
- Strives to be the single document needed to understand SaskPower's energy strategy and how it will be delivered

Outside of IRP Scope:

- SaskPower future business model
- Rate structure/design
- Business support resources and systems

SaskPower
Powering the future®

THE IRP PROCESS



CHALLENGES WITH RENEWABLES

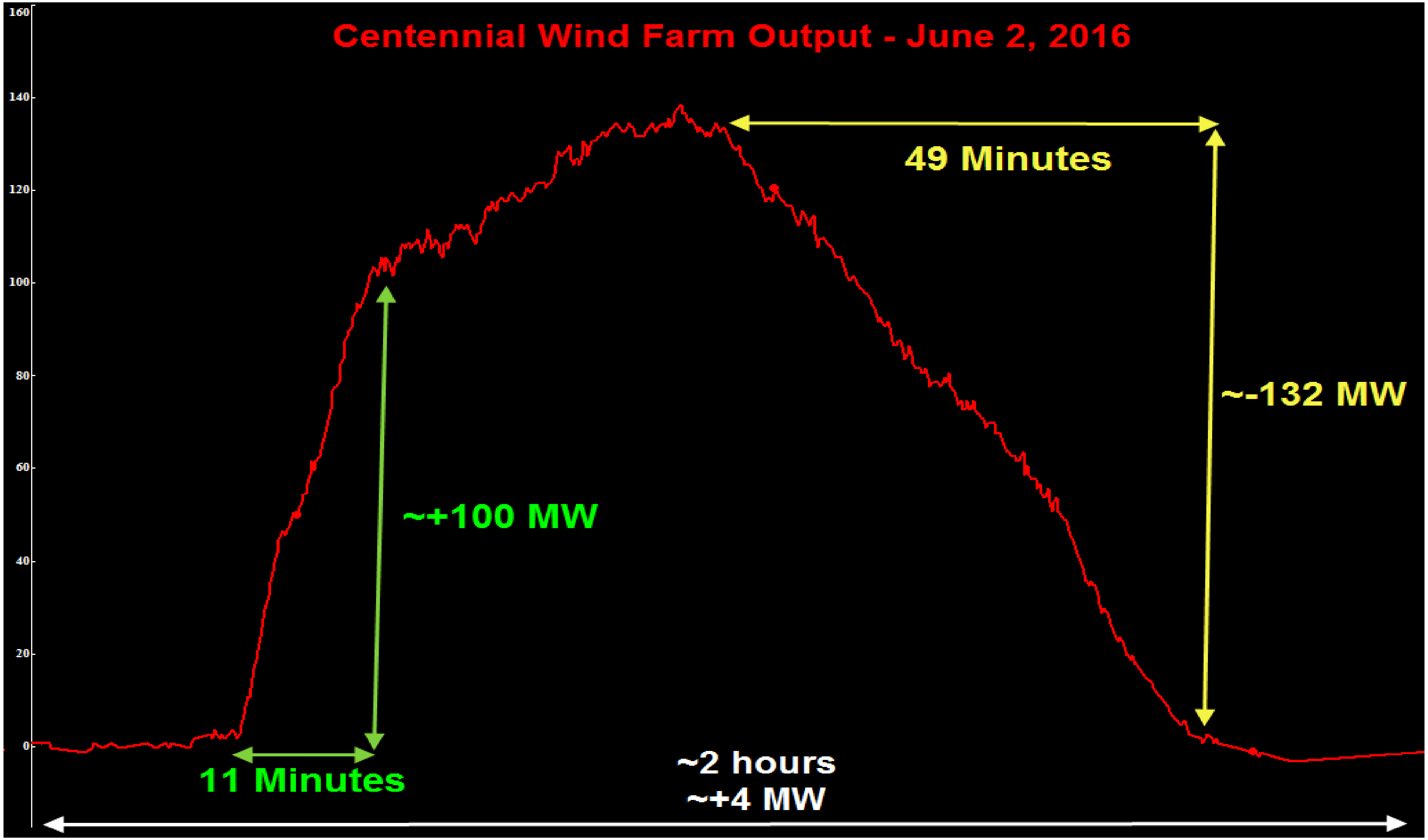
- Renewables are intermittent resources (sources of energy that are not continuously available due to factors outside the direct control of the operator).

- Not being able to directly control the fuel source corresponds to not being able to directly control the output (dispatch level).

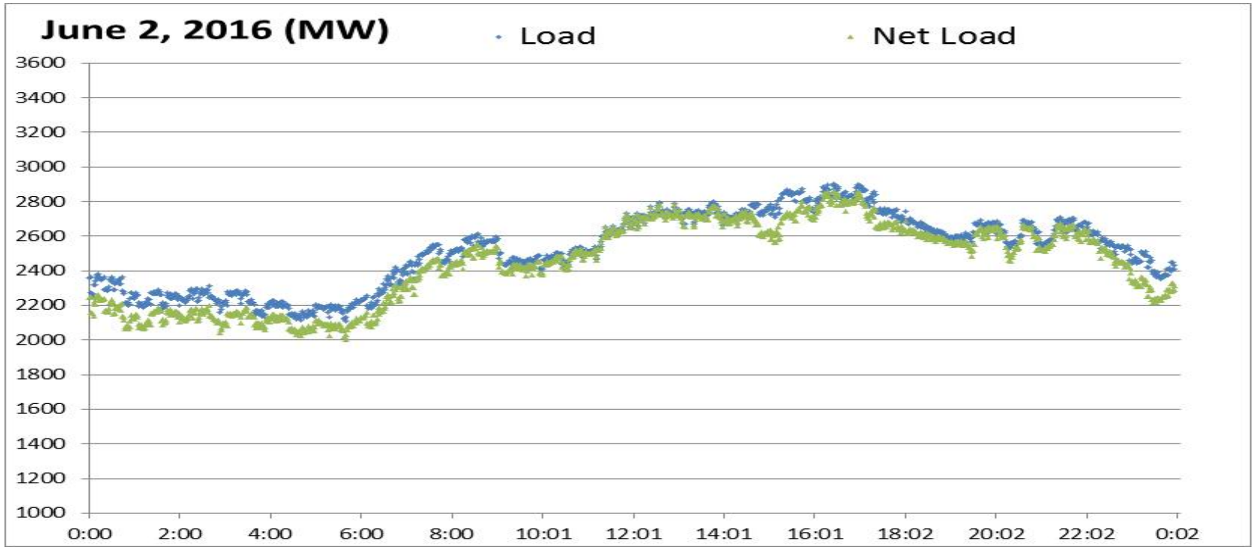
- Renewables add another factor that system operators need to account for in balancing the system (on top of variations already cause by load, generation, and transmission).

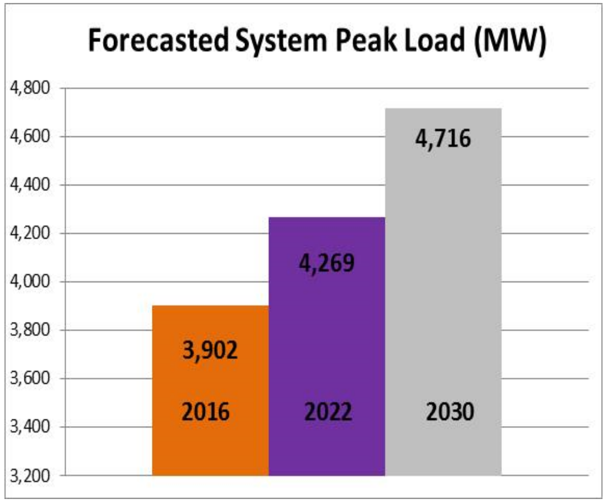
SaskPower
Powering the future®

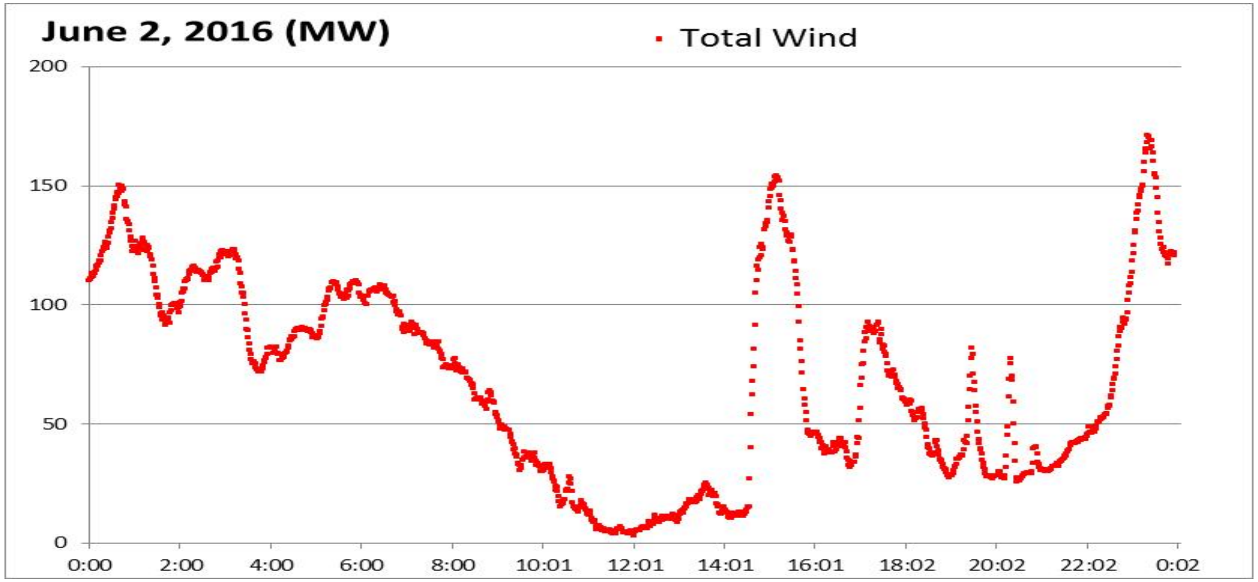
Why is intermittent generation a Concern?

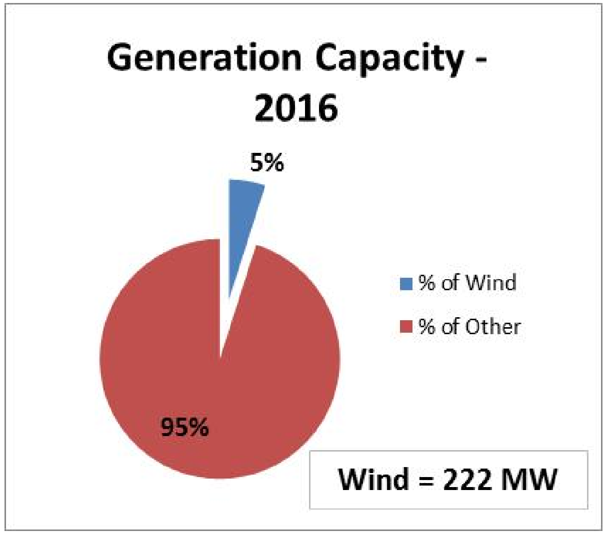


Why a Concern? (continued)

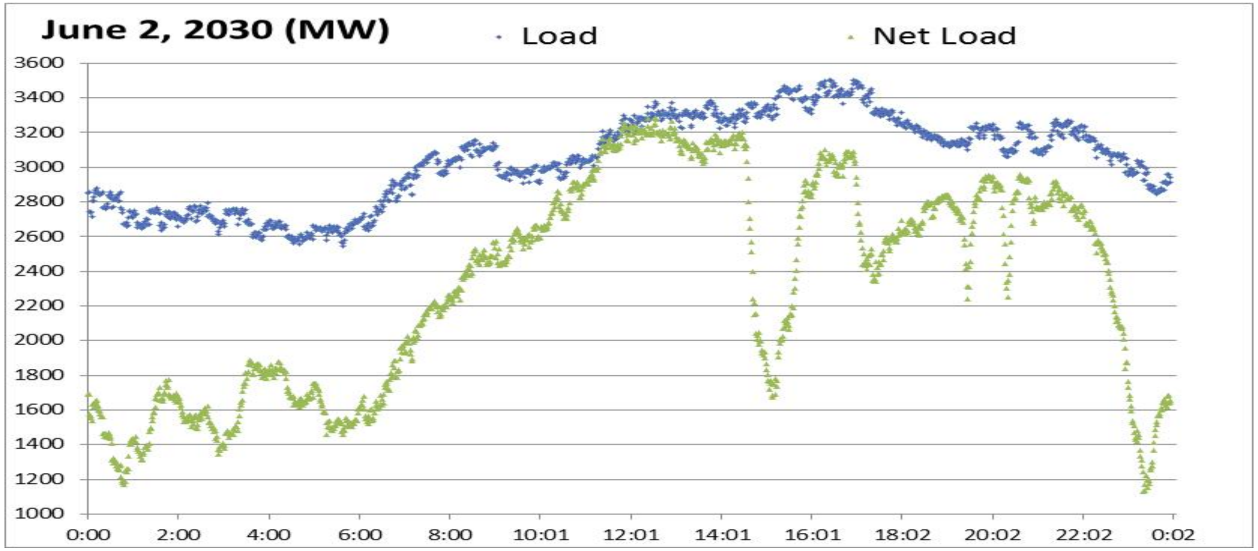


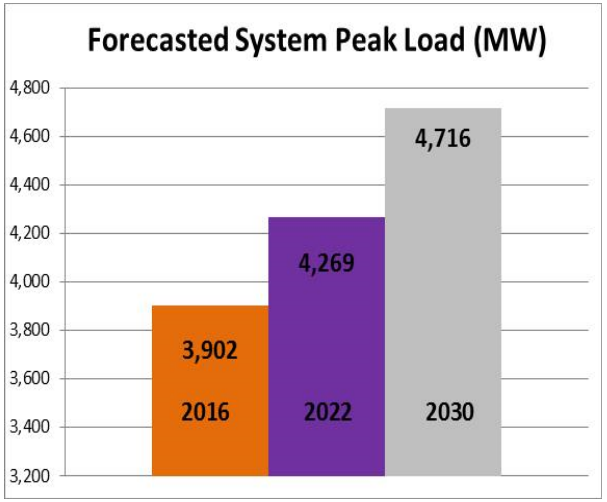


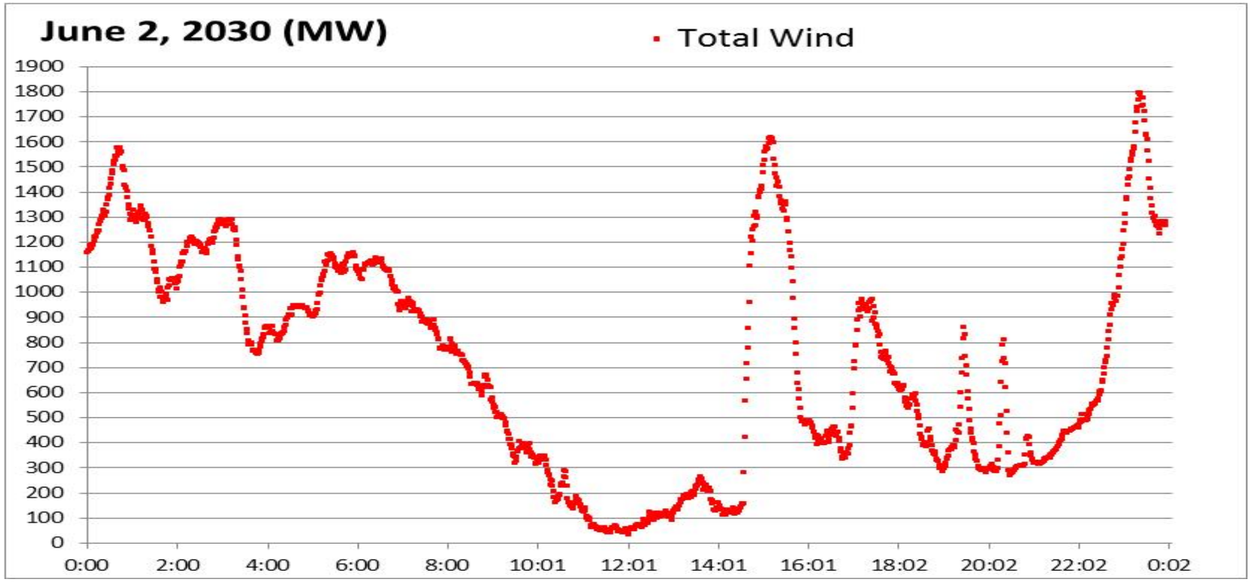


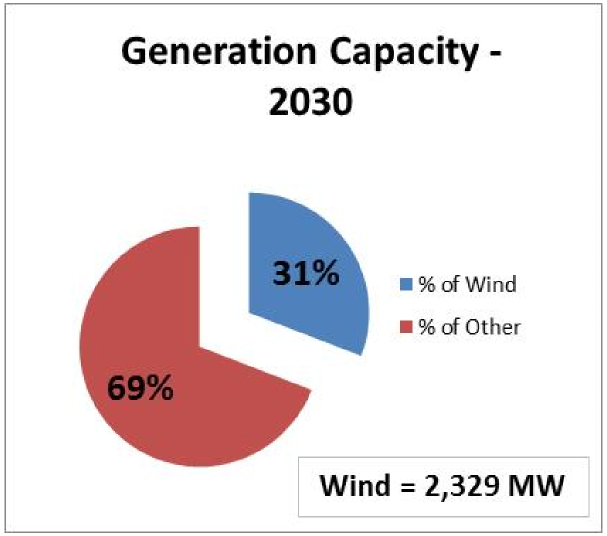


Why a Concern? (continued)









New Initiatives

Renewables Integration Study

Gain a better understanding and quantify:

- The value wind & solar bring to the system (avoided cost, capacity value, ancillary services, etc.)
- Changes expected on existing generation fleet (cycling, ramping, commitment, reserves, etc.)
- Regulating reserve requirements to manage variability
- Improved model fidelity for system planning/operations

New Modelling Tools

Exploring planning/operational modelling tools that:

- Produce simulations covering minutes to years for:
  - production cost
  - resource expansion
  - reliability
- Incorporate cascading hydro system optimization, hydro thermal coordination, and stochastic simulations.
- Facilitate detailed model components for hydro systems, reserves, thermal units, integer optimization, etc.
- Integrated tools that cover multiple analyses such as:
  - Forecast errors
  - Optimal expansion
  - Renewable forecast impacts
  - Emissions restrictions

PLEXOS® Integrated Energy Model

- A simulation software that uses mathematical optimization combined with the latest data handling, visualization, and distributed computing methods.

- Provides a high-performance, robust simulation system for electric power, water and gas.

- Meets the demands of energy market participants, system planners, investors, regulators, consultants and analysts alike with a comprehensive range of features

- Seamlessly integrates electric, water, gas and heat production, transportation and demand over simulated timeframes from minutes to 10's of years,

- All delivered through a common simulation engine with easy-to-use interface and integrated data platform.

PLEXOS
BY ENERGY EXEMPLAR

Outcomes and Considerations

Modelling will give you outcomes but can't make decisions for us!

- Gas portfolio lowest **cost** but costs go higher with carbon pricing.
- SMR portfolio lowest **emissions** but first-mover SMR projects must materialize to prevent risk.
- CCS with enhanced capture technology is higher-cost but **extends life of coal assets, industry and jobs.**
- Imports scenario has low emissions but relies on **out-of-province** decisions and jobs.
- Stronger renewables scenario = **increased costs** to customers.
- What pathway do we want to take?

Decision Drivers	Metrics
Carbon pricing/penalties	Emissions profile
Access to capital	Levelized cost/MWh
Natural gas price & volatility	Risk mitigation
Technology limitations	Operability
Public acceptance	Social licence/corporate reputation
Ability to mitigate risk	Supply mix diversification

Questions & Discussion

SaskPower

Powering the future®