Energy+Environmental Economics

Industry Trends: IRP 101

Nova Scotia Power

Stakeholder Session #2

June 28, 2019

Zach Ming, Sr. Managing Consultant
Arne Olson, Sr. Partner

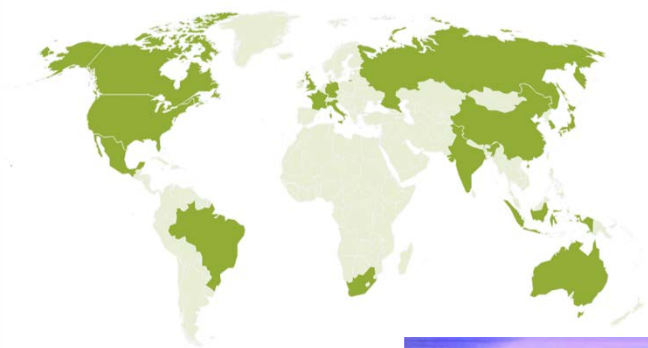
Outline

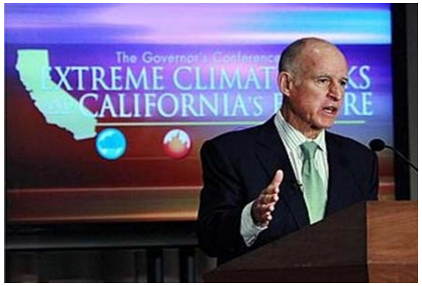
- **IRP Overview**
- **E3 Introduction**
- **Electricity Industry Trends in Long-Term Planning**
  - Challenges in Other Jurisdictions
- **Nova Scotia Power System Overview**
  - Challenges in Nova Scotia

About E3

- E3 is a San Francisco-based consulting firm founded in 1989 specializing in electricity economics with approximately 60 staff
- E3 consults extensively for utilities, developers, government agencies, and environmental groups on clean energy issues
- Services for a wide variety of clients made possible through an analytical, unbiased approach
- Our experts provide critical thought leadership, publishing regularly in peer reviewed journals and leading industry publications

SUSTAINABLE DEVELOPMENT SOLUTIONS NETWORK
A GLOBAL INITIATIVE FOR THE UNITED NATIONS
IDDRI SciencesPo.
deepdecarbonization.org





Overview of E3 Practice Areas

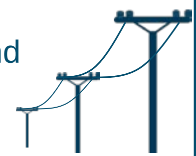
+ **E3 focuses on all segments of the electricity sector and their interconnectedness with the rest of the energy economy in order to provide holistic analysis and recommendations for our clients**

E3 has five defined working groups that create continual innovation from cutting edge projects and constant cross-fertilization of best practices across the groups

DERs & Rates

Analyzes distributed energy resources, emphasizing their costs and benefits now and in the future

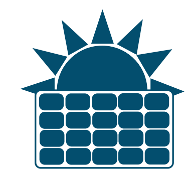
Supports rate design and distribution system planning



Clean Energy

Provides market and policy analysis on clean energy technologies and climate change issues

Includes comprehensive and long-term GHG analysis



Asset Valuation

Determines asset values from multiple perspectives

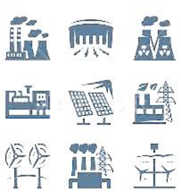
Uses proprietary in-house models and in-depth knowledge of public policy, regulation and market institutions

$

Planning

Develops and deploys proprietary tools to aid resource planners

Informs longer-term system planning and forecasting



Market Analysis

Models wholesale energy markets both in isolation and as part of broader, more regional markets

Key insights to inform system operators and market participants

E3 Experience in Resource Planning

+ **E3 has worked with a wide range of clients that are increasingly writing the script for the emerging clean energy transition to understand how to plan deeply decarbonized electricity systems**
  - **California PUC:** Assisting the CPUC in administration of IRP program mandated by SB 350 by developing a 'Reference System Plan' that achieves 40% GHG emission reductions by 2030 using the RESOLVE model
  - **Pacific Northwest Low Carbon Scenarios Study:** Retained to investigate the economics of Swan Lake and Goldendale "closed-loop" pumped storage hydro projects (1,600 MW total) in Oregon and Washington
  - **Sacramento Municipal Utilities District:** Assisting with 2018 IRP to evaluate long-term clean energy goals including GHG emission reductions of 90-100% by 2040
  - **Los Angeles Department of Water and Power (LADWP):** Evaluated reliability contributions of clean energy alternatives to natural gas once-through-cooling plant repowerings
  - **Hawaiian Electric Company (HECO):** Developed an affordable, technical feasible Power Supply Improvement Plan (PSIP) consistent with Hawaii's goal of 100 percent renewable energy by 2045
  - **Xcel Energy Upper Midwest IRP:** Provided support to Xcel Minnesota by conducting independent technical analysis to examine how to meet long-term carbon reduction goals along with associated costs as part of their 2019 IRP process

+ **Through these projects, E3 has developed an unparalleled understanding of the role of storage within highly and deeply decarbonized renewable electricity systems**

Key E3 Staff Bios

Arne Olson
Senior Partner

Mr. Olson leads E3's resource planning practice. Since joining E3 in 2002, he has led numerous analyses of how renewable energy and greenhouse gas policy goals could impact system operations, transmission, and energy markets.

M.S. in international energy management and policy from the University of Pennsylvania and the Institut Francais du Petrole and a B.S. in statistics and mathematical sciences from the University of Washington

Zach Ming
Senior Managing Consultant

Mr. Ming leads the development of energy models and communicates findings on behalf of utilities, regulatory agencies, and trade groups. Since joining E3 in 2013, he has managed numerous resource planning projects and teaches a class at Stanford University on electricity economics.

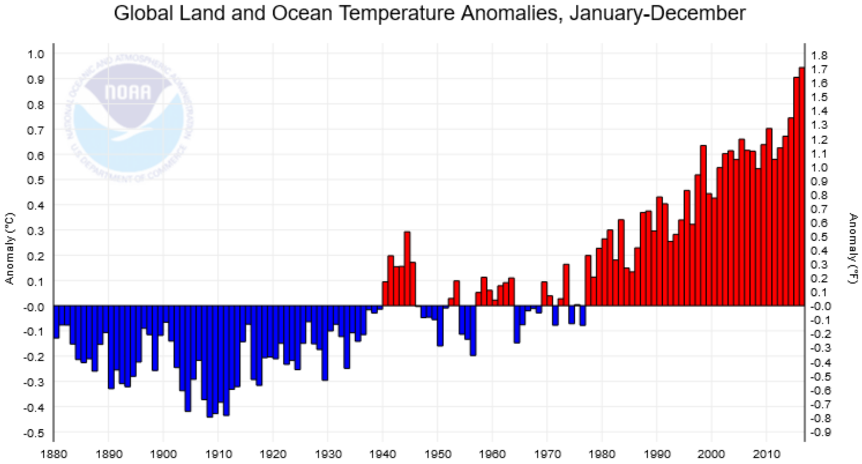
M.S. in management science and engineering and a B.S. in civil and environmental engineering from Stanford University.

Energy+Environmental Economics

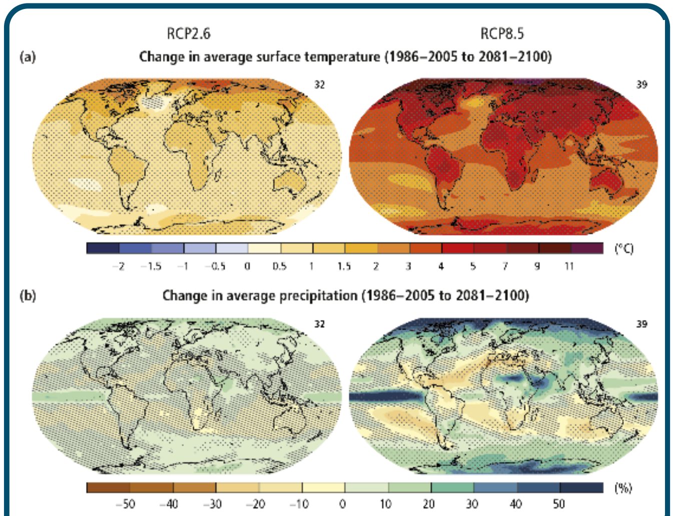
Trends in the Electricity Industry

Decarbonization

- **The 2016 Paris agreement committed industrialized nations to 80% reductions below 1990 levels by 2050**
  - Roughly consistent with IPCC/UNFCC goal of keeping global average temperature rise within 2°C to avert catastrophic climate change
- **If current trends continue, 2°C aggregate warming will be exceeded**



Source: NOAA, https://www.ncdc.noaa.gov/monitoring-references/faq/indicators.php Global annual average temperature measured over land and oceans. Red bars indicate temperatures above and blue bars indicate temperatures below the 1901-2000 average temperature.



Source: IPCC Global Assessment Report 5, SPM.07

Declining Prices of Renewables and Energy Storage

Levelized Wind PPA Prices by PPA Execution Date

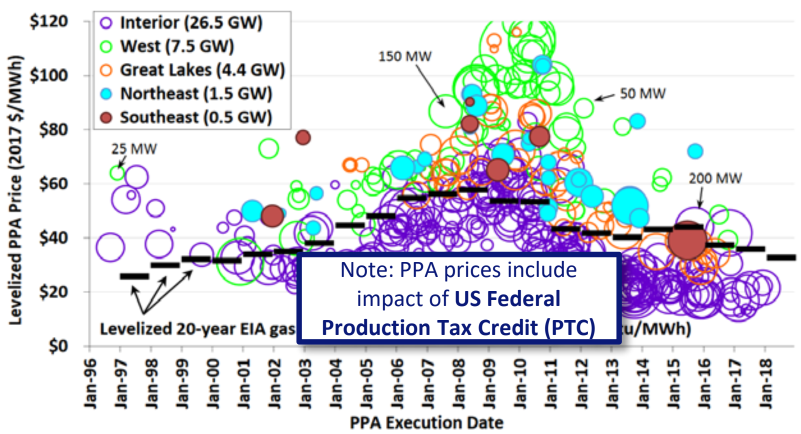


Figure source: 2017 Wind Technologies Market Report (LBNL)

- Declining prices of clean energy technologies such as wind, solar, and energy storage is leading to aggressive renewable energy policies and targets as well as adoption on the basis of economics alone in many jurisdictions

NREL Utility-Scale PV System Cost Benchmark Summary (Inflation Adjusted), 2010-2018

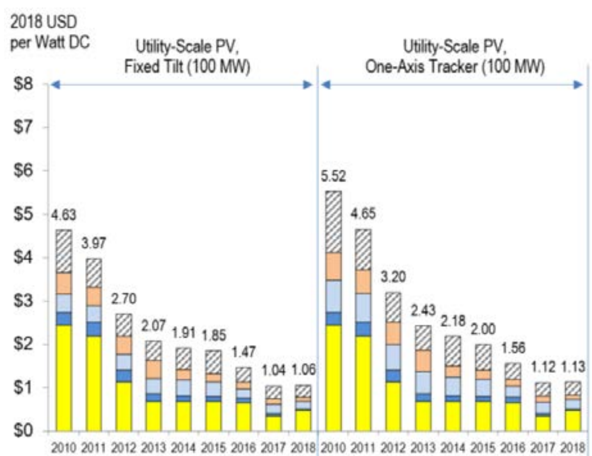


Figure source: US Solar Photovoltaic Cost Benchmark: Q1 2018 (NREL)

Lithium-Ion Battery Price, Historical and Forecast, 2010-2030

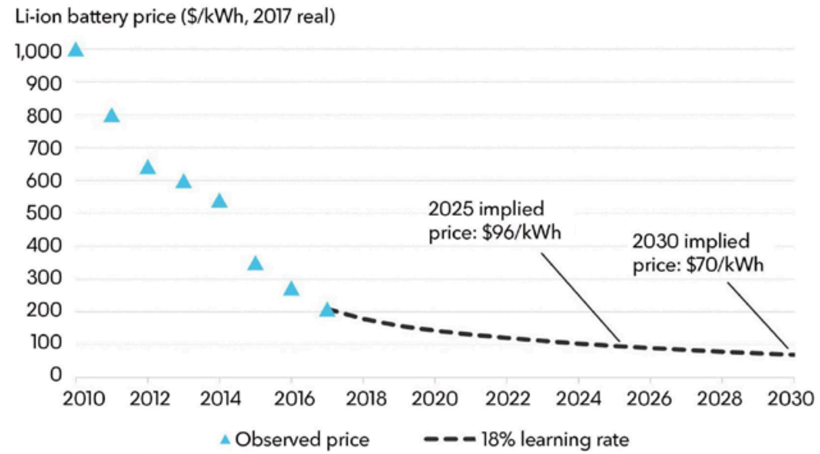
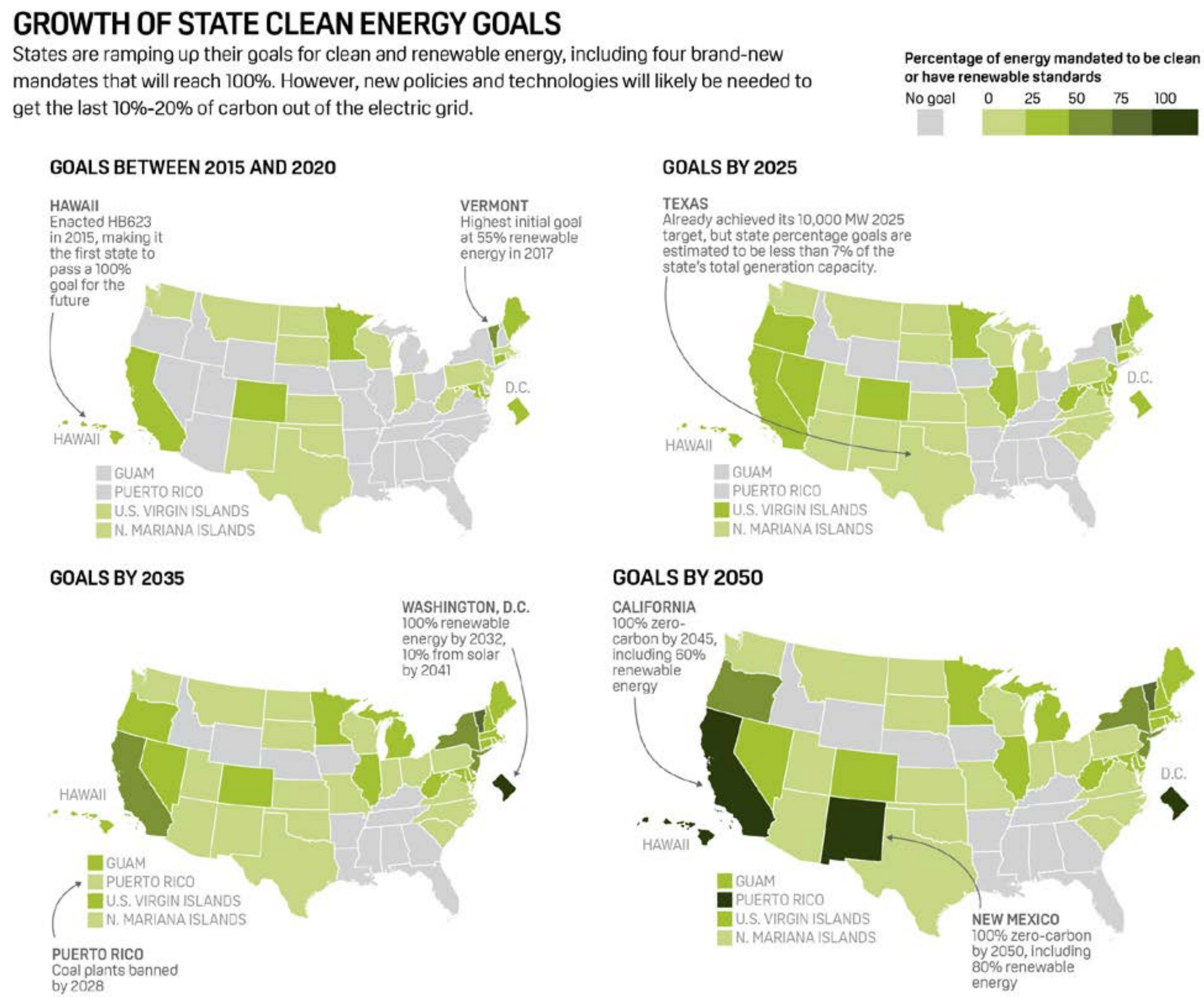


Figure source: Bloomberg NEF

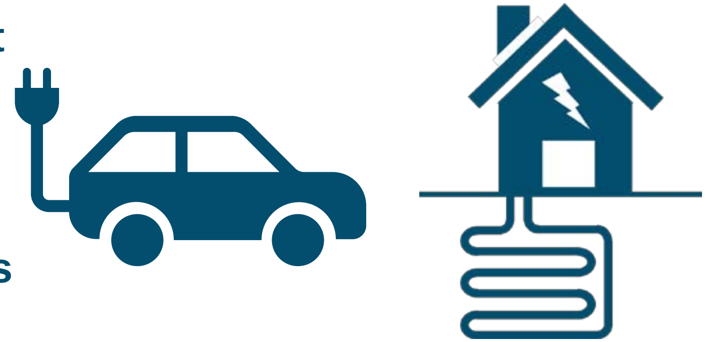
High-Volume Renewable Targets

- **Many states are pushing beyond existing RPS policies and goals into “high-volume” targets of 50%-100%**
- **100% clean electricity targets**
  - California
  - New Mexico
  - Washington
  - Xcel Energy
  - Idaho Power
  - Many municipalities
  - *…New York*
  - *…Illinois*

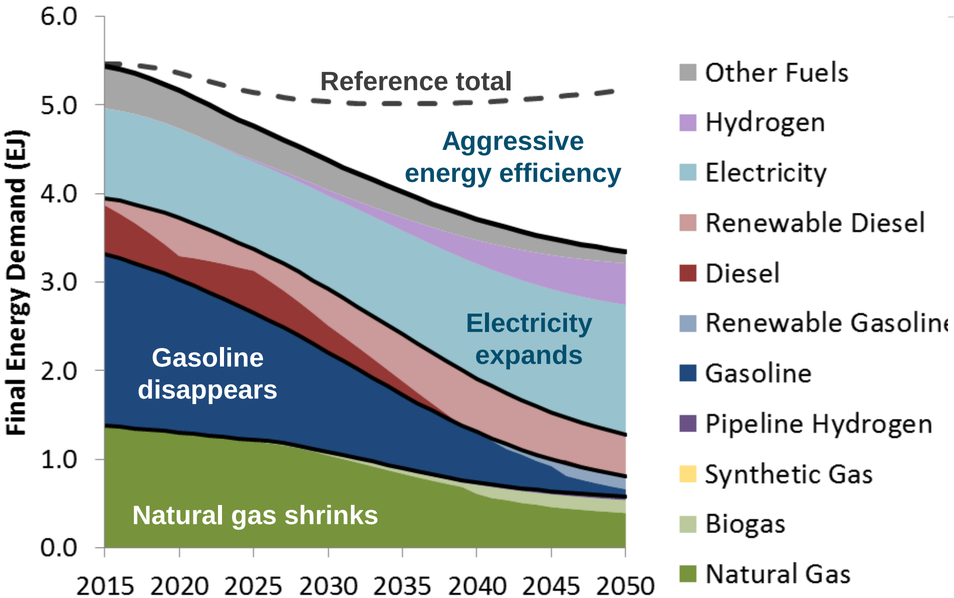


Electrification

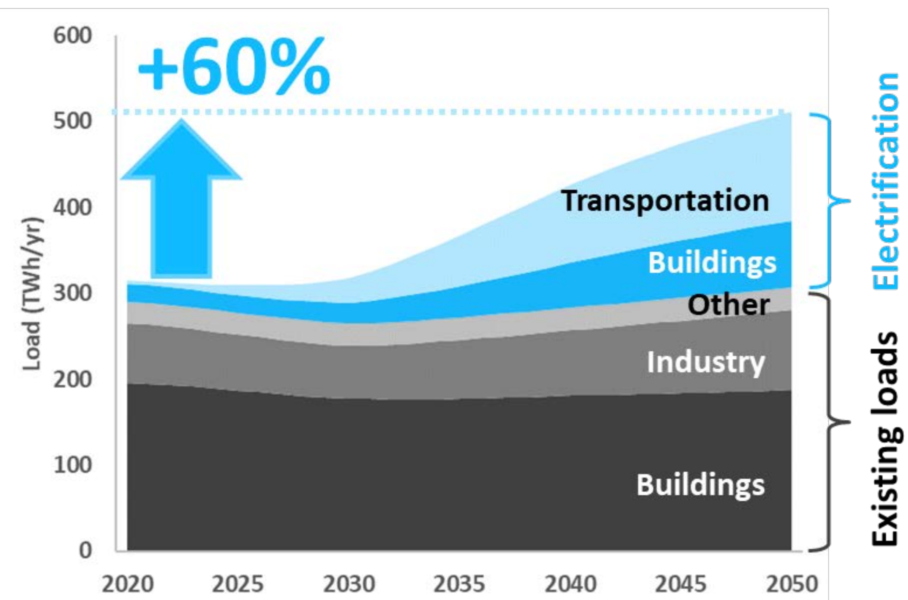
- A growing consensus of economy-wide decarbonization studies show the important role that electrification of vehicles and buildings will play in a least-cost plan
- In many jurisdictions, total electricity demand is expected to grow in the long-run despite investments in energy efficiency



Final Energy Demand by Major Fuel Type
80% GHG Reduction Case in California



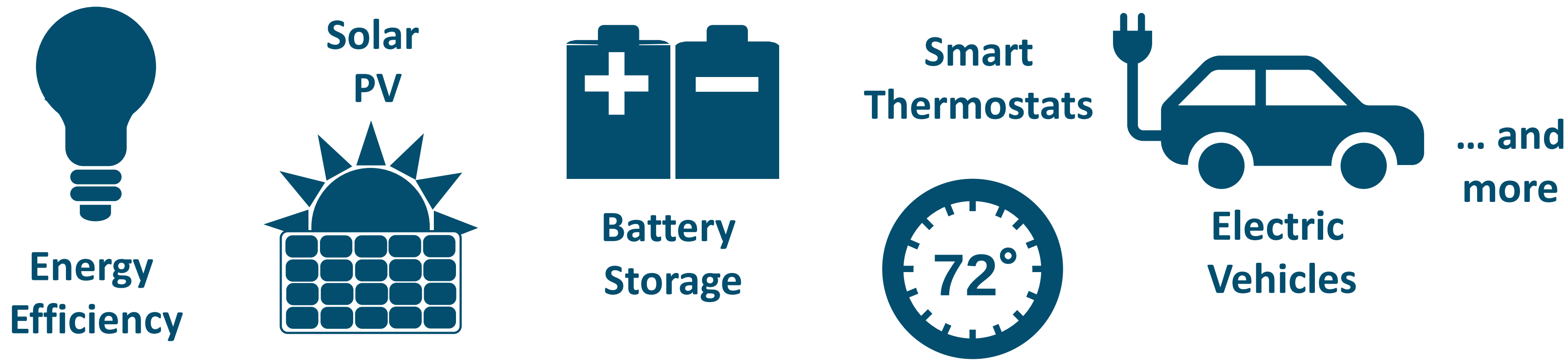
Final Electricity Demand
80% GHG Reduction Case in California



Source: E3 PATHWAYS

Distributed Energy Resources

- DERs are technologies located close to customer load or on the customer side of the electricity meter i.e. behind-the-meter



- DERs have gained popularity in recent years buoyed by technological advances (sensors, monitors, communication), price declines (solar PV, battery storage), and changing customer preferences (cleaner, cheaper, independent)
- DERs that are responsive to the needs of the grid through flexibility and communication have the potential to play a key role in the integration of renewable energy for decarbonization
  - Smart thermostats that pre-heat or pre-cool a home
  - Electric vehicles and water heaters that charge when it's sunny or windy
  - Appliances such as dishwashers that delay operation until system demand is lower

TESLA

IceEnergy

Retail Rate Structures

+ **Reforms to existing retail rate structures will be necessary to enable both electrification and renewable energy in the future**

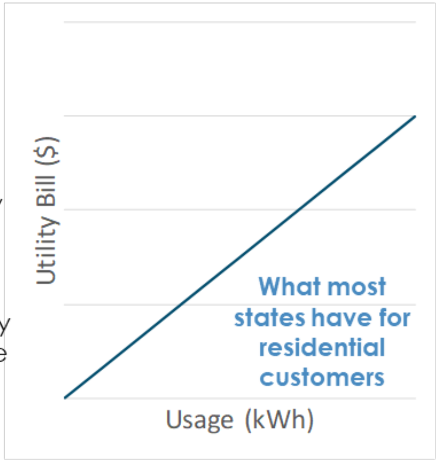
Volumetric

Pros

Simple, relatively fair when customers are homogenous, good incentives for efficiency and solar

Cons

Poorly aligned with utility costs, cannot incentivize flexible loads, can create cost-shifts and cross-subsidies



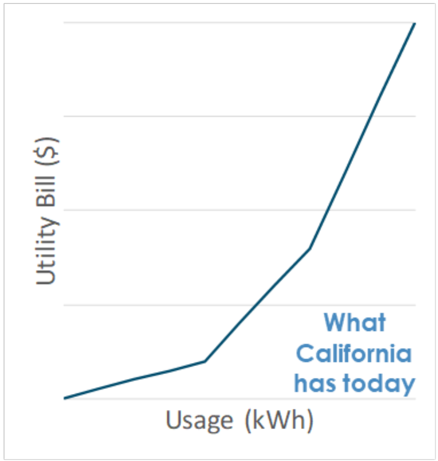
Tiered

Pros

Really good at incentivizing efficiency and solar, progressive (larger, wealthier customers pay more)

Cons

Extremely poorly aligned with utility costs, cannot incentivize flexible loads, can create cost-shifts and cross-subsidies



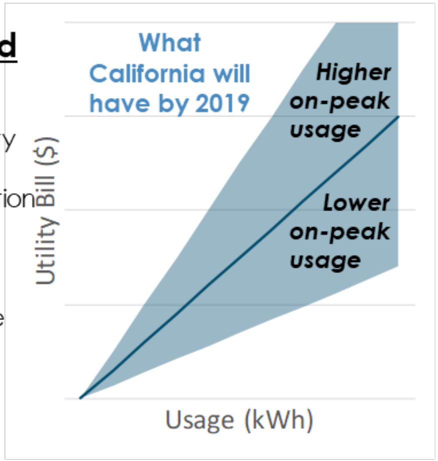
Time Differentiated

Pros

Better aligned with utility costs, can incentivize flexible loads, fair allocation of costs to customers

Cons

Complex, can remove existing incentives for efficiency and solar



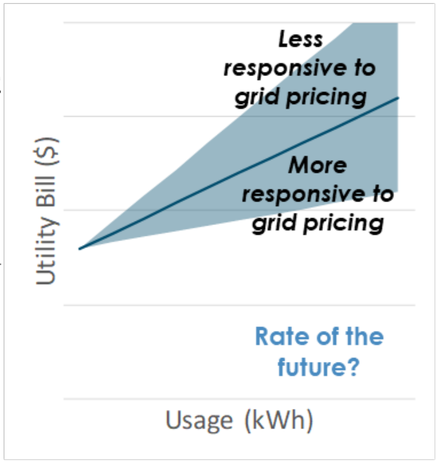
Fixed/Demand Charge & Real Time Pricing

Pros

Most economically efficient, fair allocation of costs to customers, best at incentivizing flexible loads

Cons

Complicated, poor incentive for efficiency and solar

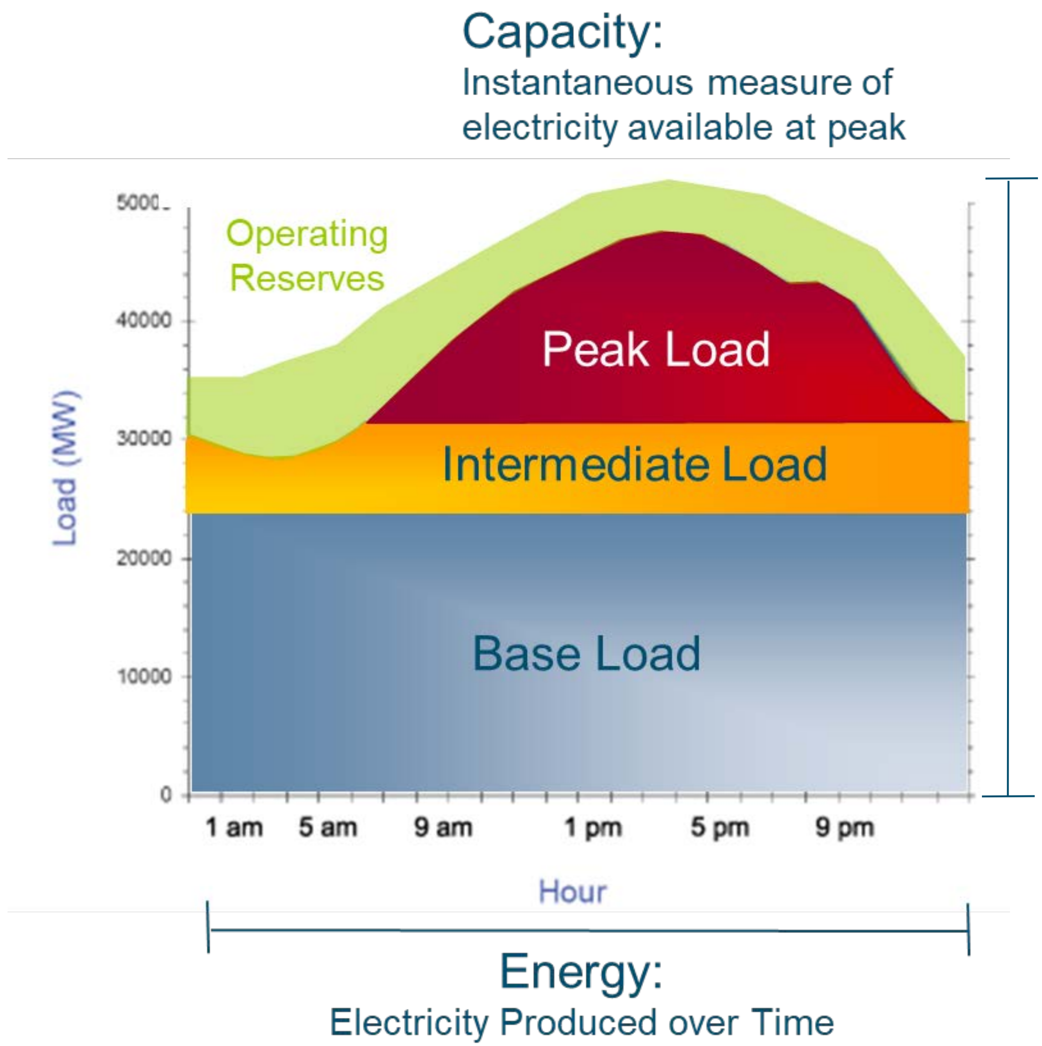


Energy+Environmental Economics

IRP 101

Basic Anatomy of a Resource Plan

+ **<u>Energy Needs:</u> portfolio of resources dispatched to meet utility annual load in each year (comprising owned resources, contracts, and market purchases)**
  - Reflects expected operations of plans based on operational characteristics as well as utility interactions with wholesale markets
+ **<u>Capacity Needs:</u> portfolio of resources available to meet peak demand (plus a planning reserve margin) in each year**
  - Planning reserve margin in Nova Scotia is 20% above peak load
    - -15° C on January weekday evening



Source: NERC

Emergence of Integrated Resource Planning

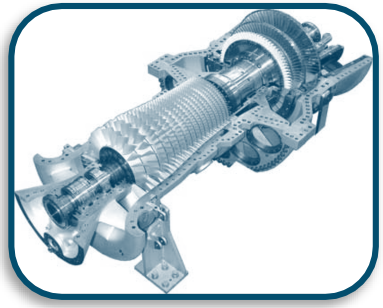
- **The concept of integrated resource planning "IRP" emerged in the 1980's, bringing a new suite of demand-side resources to the table as options in planning**
- **Today, some – but not all – utility IRPs consider supply and demand-side resources on a level playing field**
  - More often, demand-side resources are evaluated in a separate step and integrated into the planning process as assumptions

The Traditional Planning Paradigm

+ **Historically, utility planners have built electricity resource portfolios with 3 types of resources by weighing fixed and variable cost**

Baseload
coal, nuclear

Intermediate
combined cycle gas



Peaker
combustion turbine gas

Increasing **variable** costs →

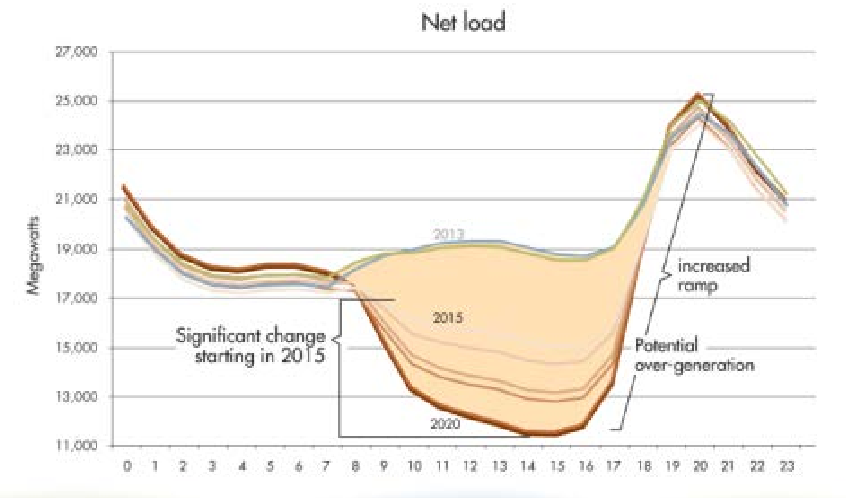
← Increasing **fixed** costs

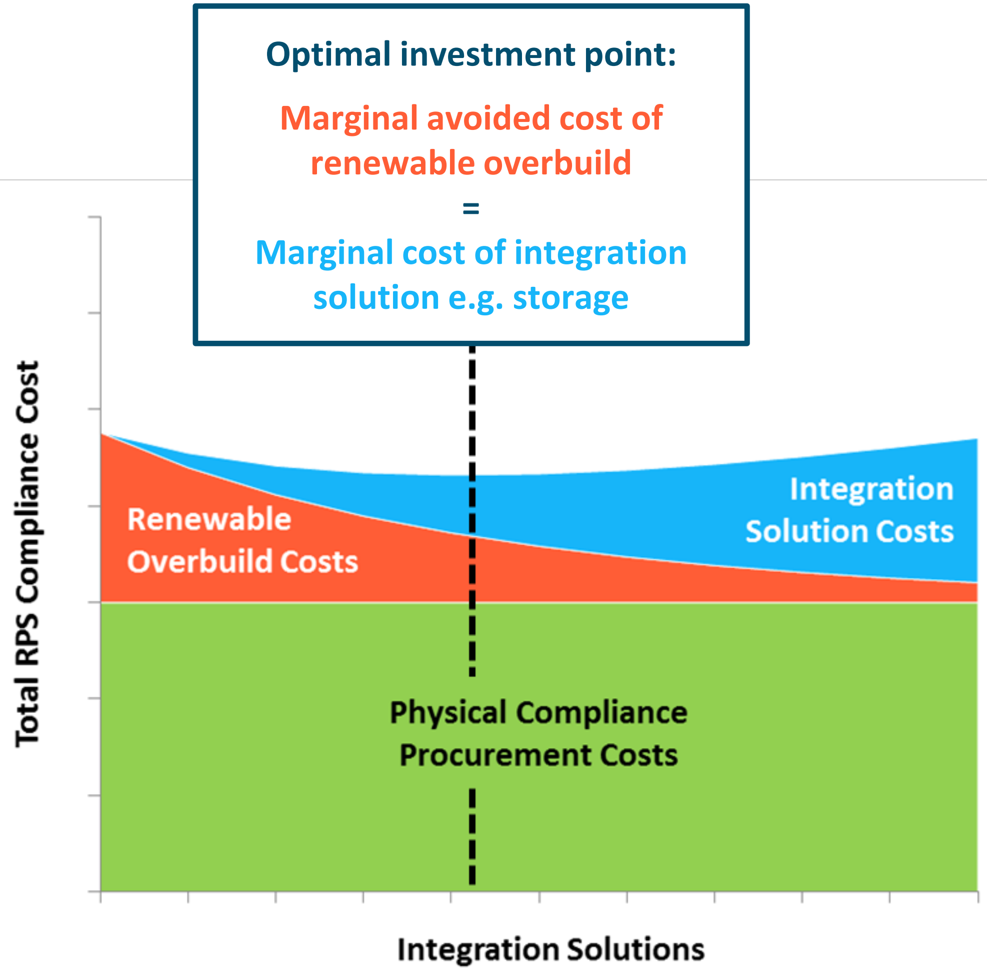
+ **Similar question to which type of coffee is more expensive – how often do you drink coffee?**

vs.

New Trends in Resource Planning

+ **New constraints added to the optimization**
  - Emission targets/caps
  - Emission taxes
  - Renewable energy targets
+ **Complexities associated with modeling variable renewable energy sources and storage with limited duration**

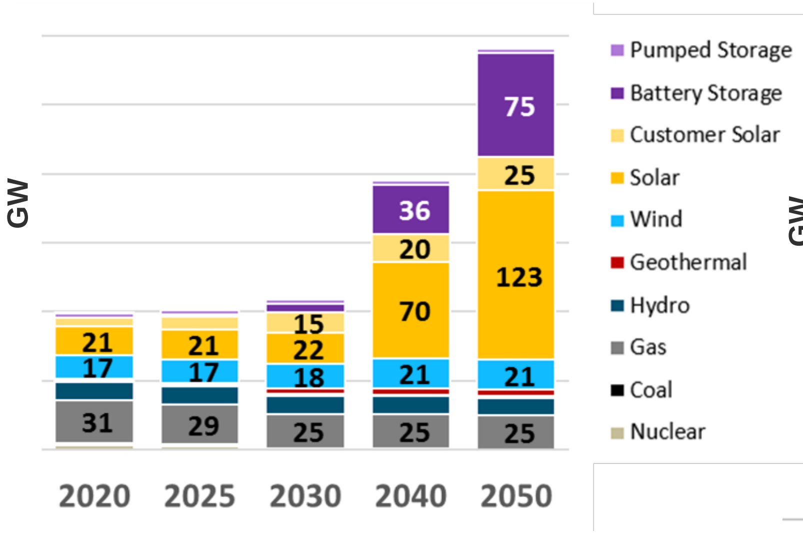




- A new class of "capacity expansion" models are emerging that can accurately incorporate the complex challenges associated with renewables, hydro, storage, and other demand-side resources
- These models can develop least-cost portfolios that simultaneously satisfy constraints such as reliability and emission/renewable targets

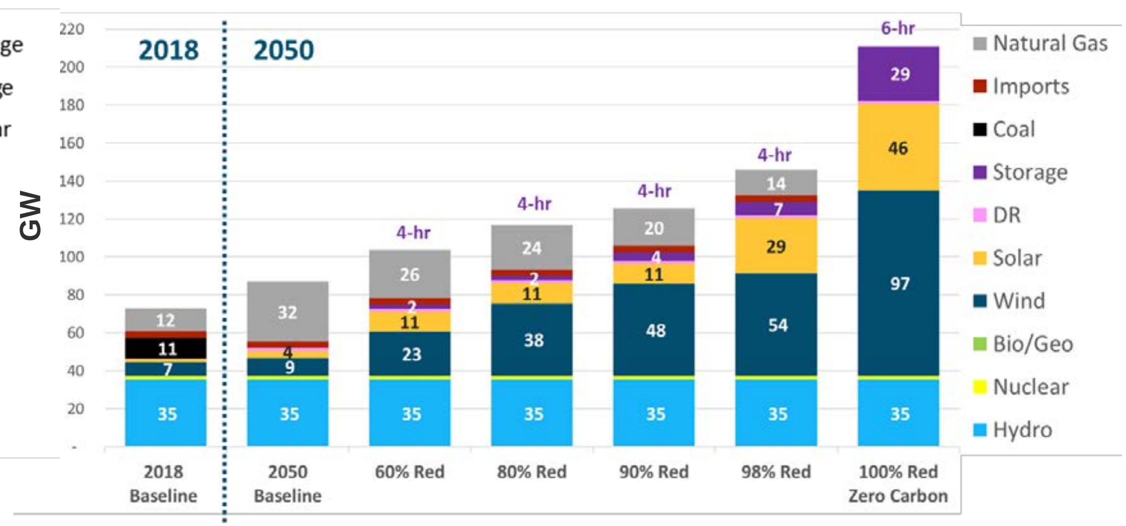
California Case Study

80% Decarbonization



Pacific Northwest Case Study

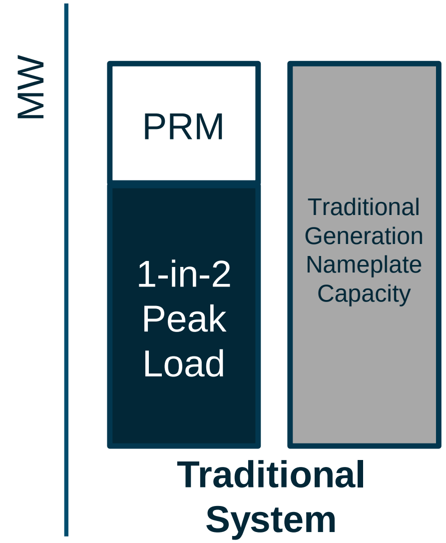
Various Decarbonization Targets



Source: E3 RESOLVE/RECAP

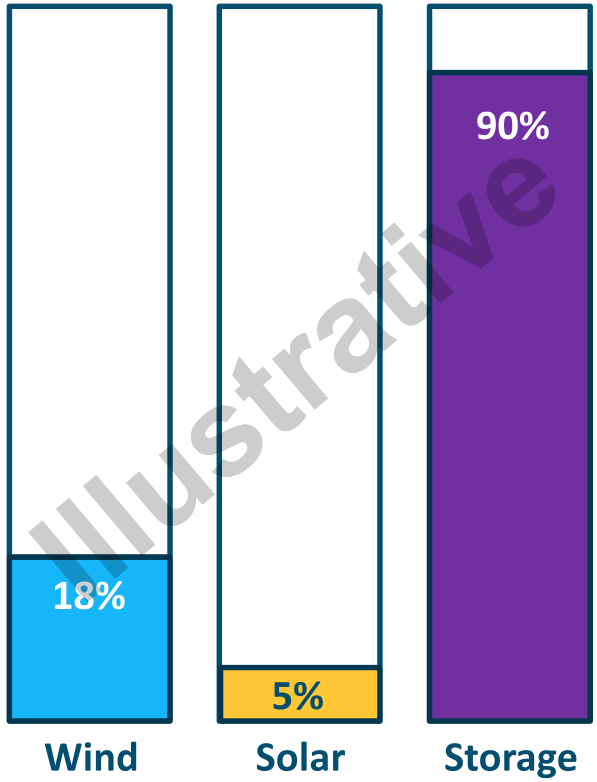
Planning Reserve Margin (PRM)

+ **Planning reserves are resources held by the utility above the forecasted median peak load that help maintain reliability even in the event of:**
  - Unplanned forced generator outages
  - Higher than normal peak loads (very cold weather)
  - Operating reserve requirements
+ **PRM is a convention that is typically based on:**
  - Installed capacity of traditional generation vs. 1-in-2 median peak load (e.g. half of the years experience a peak load higher than this and half lower)
+ **PRMs vary by utility but typically range from 12%-20+% depending on system characteristics**
  - Larger systems with more load and resource diversity can generally maintain lower PRMs
  - Islanded systems with limited interconnections and load and resource diversity such as Hawaii must maintain a PRM around 40%



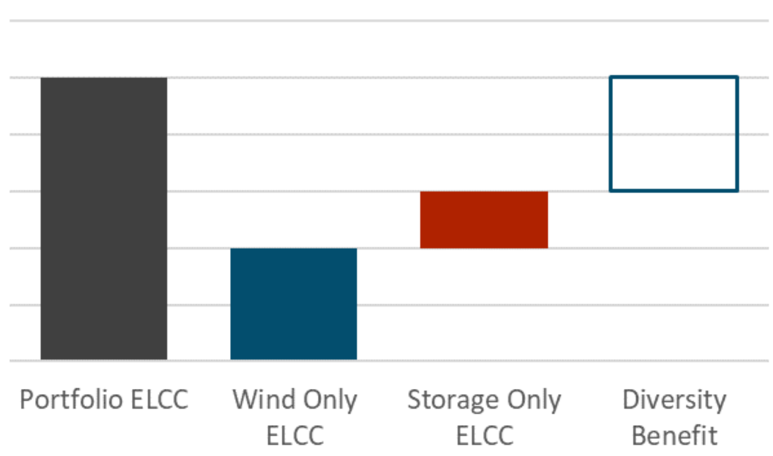
Renewable/Storage Contribution to PRM

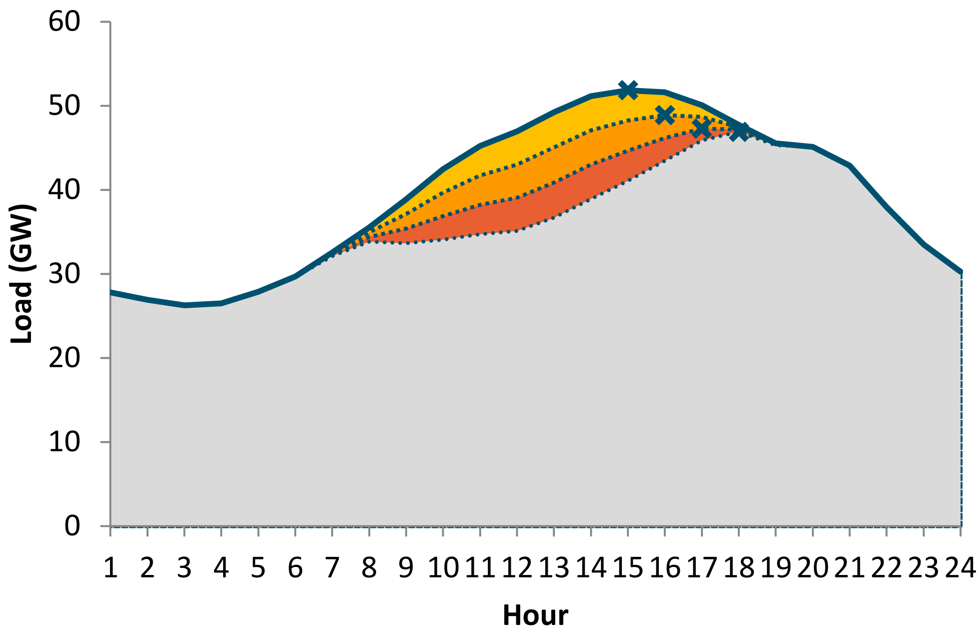
- **In systems with high penetrations of renewable energy and storage, utilities must still maintain acceptable reliability through a planning reserve margin**
- **Effective load carrying capability (ELCC) measures a resource's ability to contribute to PRM**
- **ELCC is the quantity of "perfect capacity" that could be replaced or avoided with renewables or storage while providing equivalent system reliability**
  - A value of 50% means that the addition of 100 MW of that resource could displace the need for 50 MW of firm capacity without compromising reliability
- **Calculating ELCC requires computationally intensive models that can accurately account for the correlation and probability of production between load and renewables**

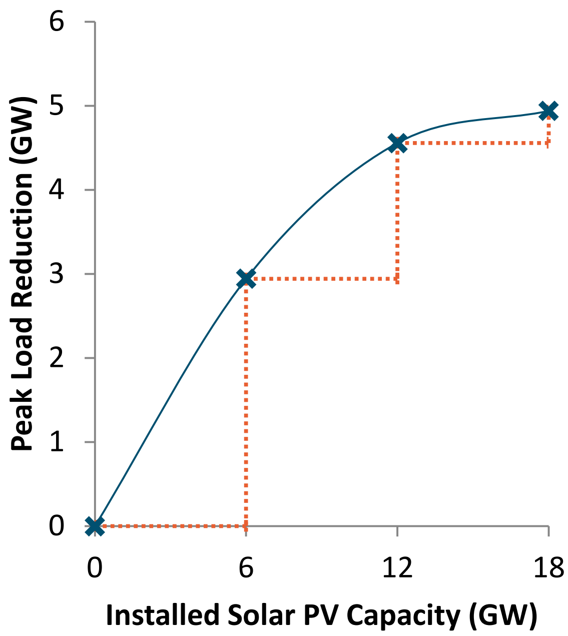


Diminishing Marginal ELCC and Diversity Benefits of Renewables/Storage

- **The ELCC of renewables or storage depends on the other resources on the system**
- **The diminishing marginal peak load impact of solar PV is illustrative of this concept**
- **There are also diversity benefits between resources such that the total contribution of a portfolio of resources may be more than the sum of their parts**

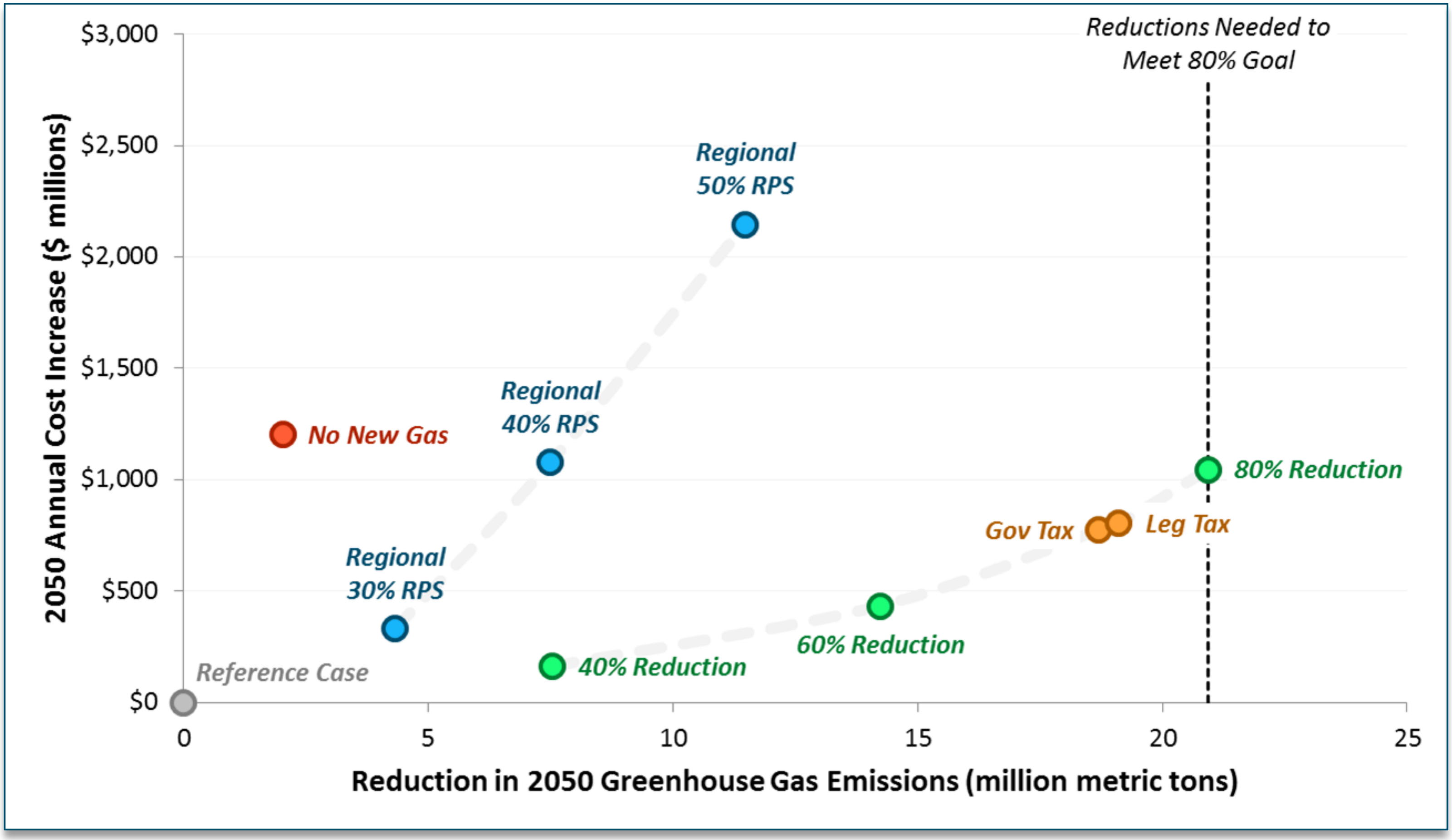






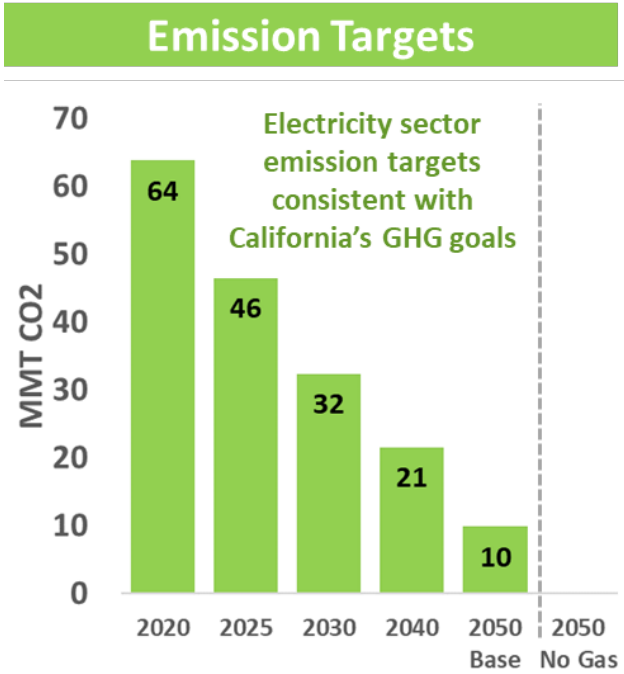
Putting it All Together

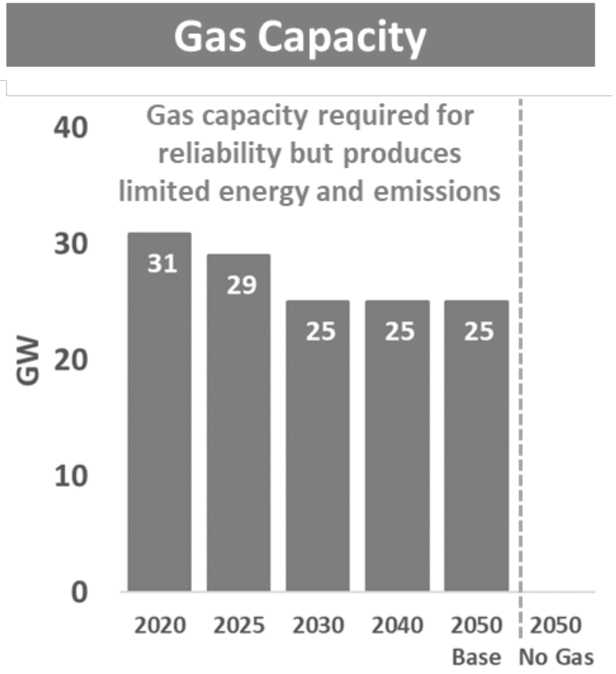
+ **IRP must accurately evaluate the energy, capacity, and emission requirements and construct a portfolio of resources that satisfy these constraints at least-cost**

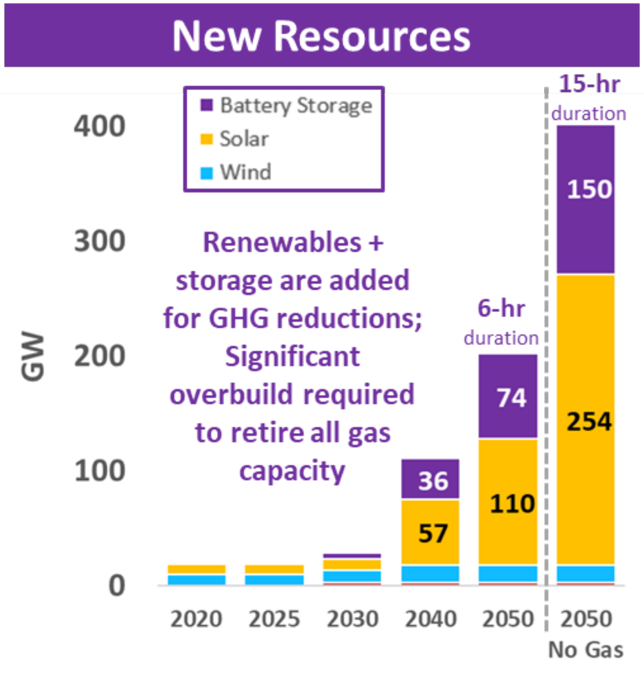


Key Challenges for California

- Least-cost plan for achieving 2050 economy-wide goals of 80% GHG reductions below 1990 levels requires electricity-sector reductions of 90-95%
- Significant quantities of renewables + storage is required, but firm capacity is still needed for reliability
- Natural gas is the most economic source of firm capacity

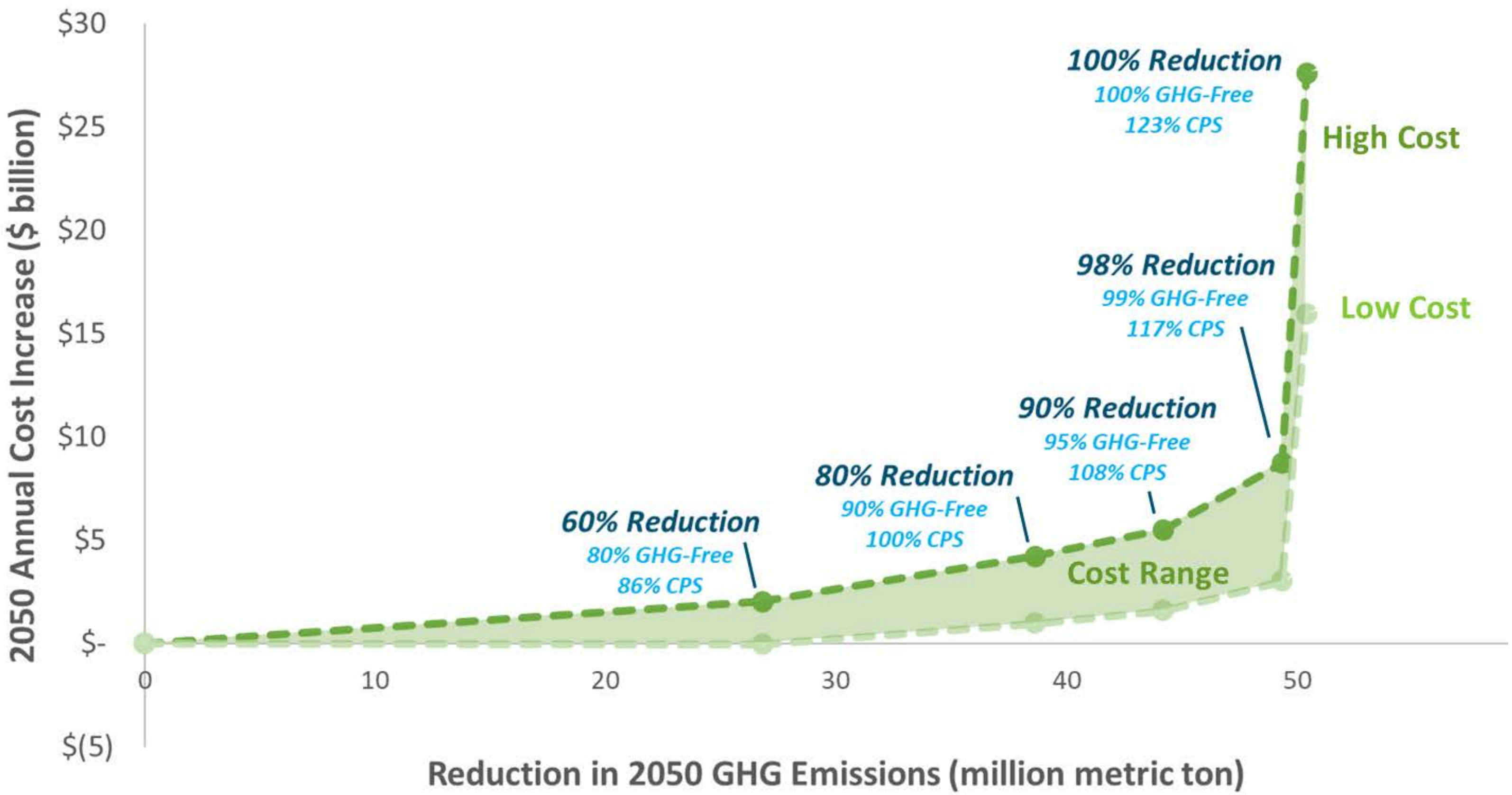






Key Challenges for the Pacific Northwest

- **Significant quantities of renewables + storage is required to achieve GHG reductions, but firm capacity is still needed for reliability**
  - Due to retirement of coal, new natural gas capacity is part of a least-cost portfolio up to 98% GHG reductions
- **Replacing all firm capacity with renewables + storage only (100%) is extremely costly due to overbuild and curtailment**



Energy+Environmental Economics

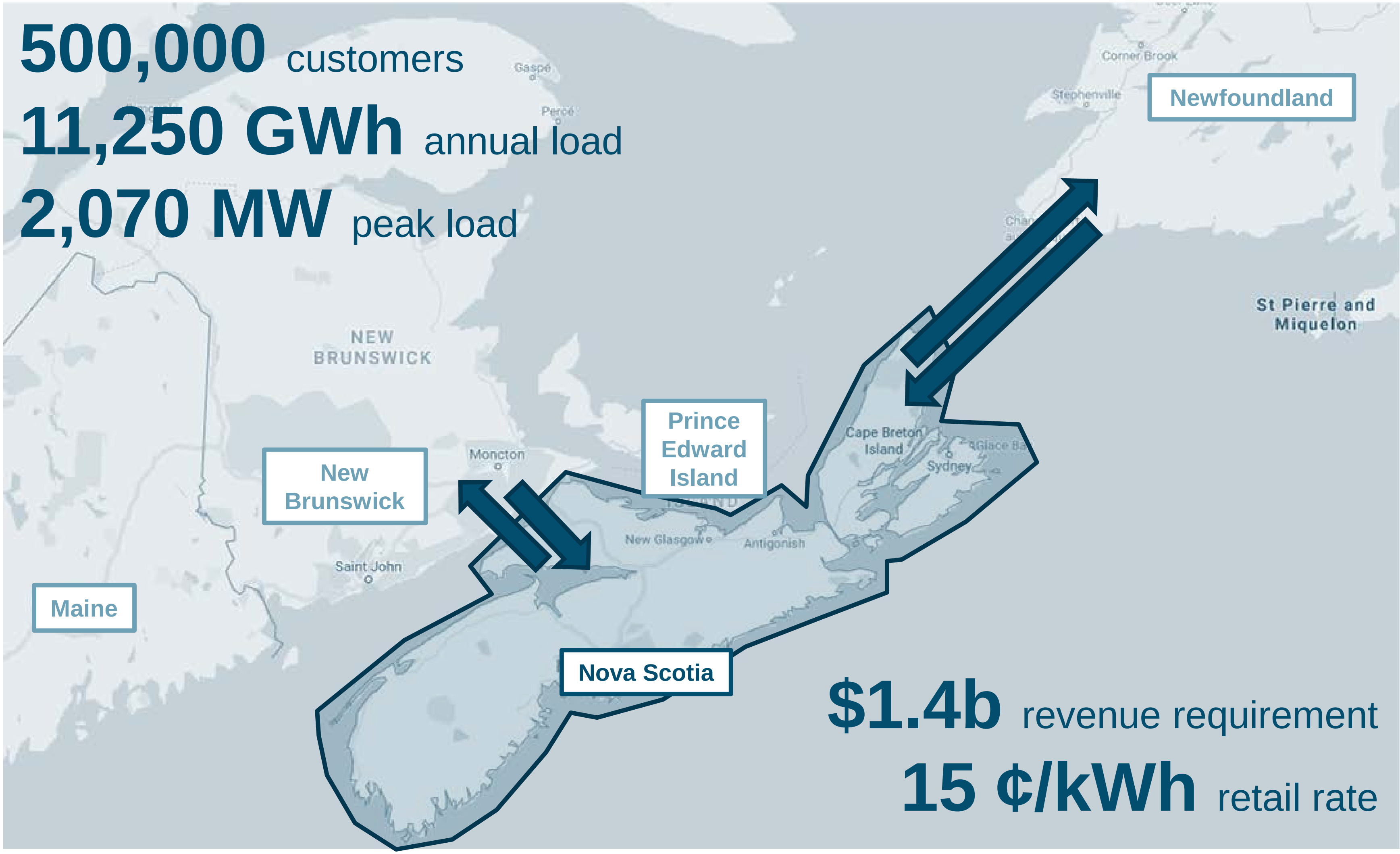
NSPI System Overview and Coming Challenges

Overview of Nova Scotia System

500,000 customers

11,250 GWh annual load

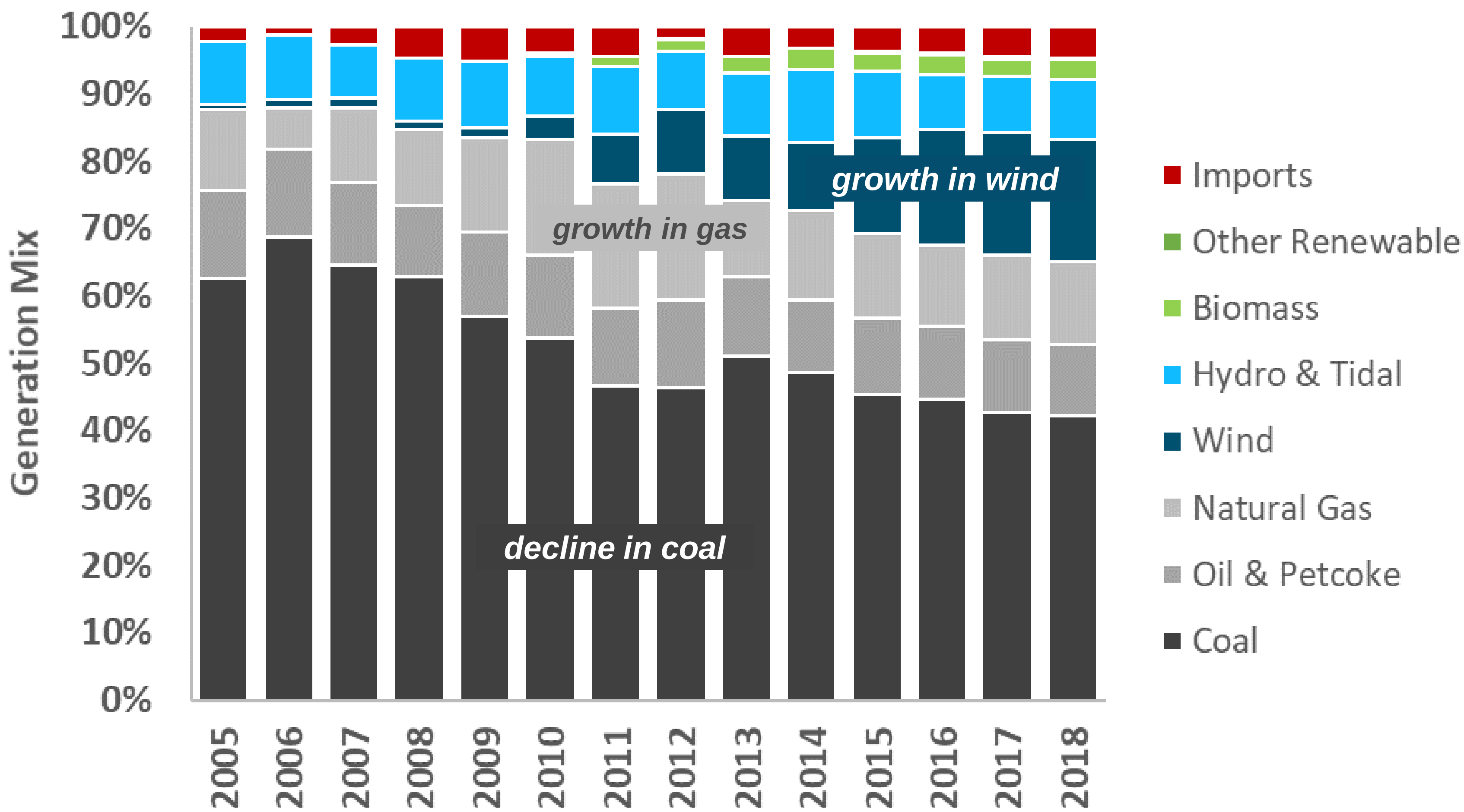
2,070 MW peak load



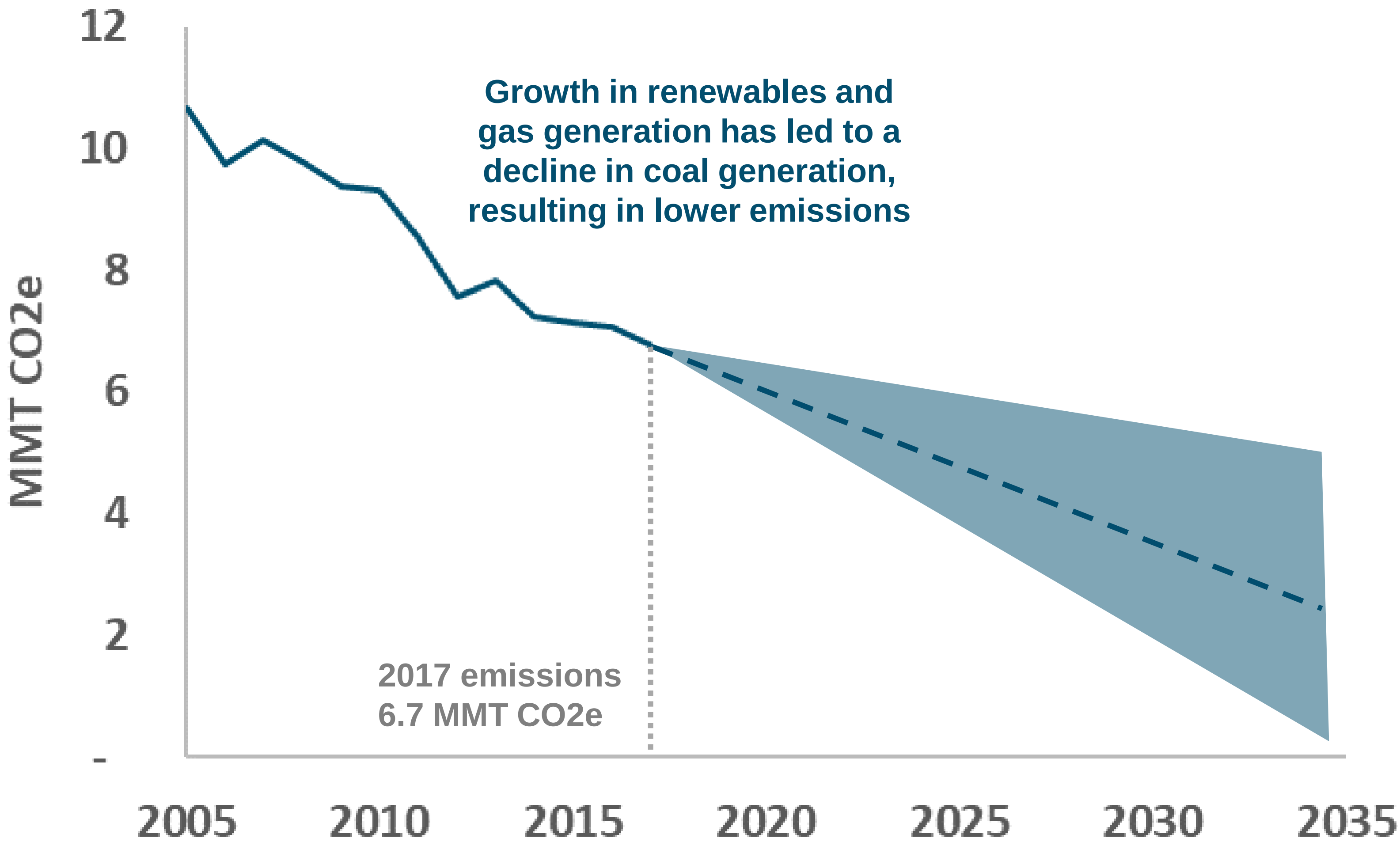
$1.4b revenue requirement

15 ¢/kWh retail rate

Generation Mix in Nova Scotia



GHG Emissions in Nova Scotia



NSPI Load and Resources

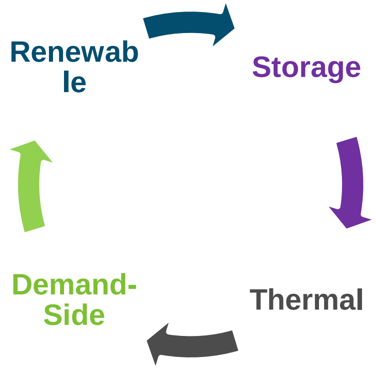
Load		NSPI 10-Yr Outlook	
Firm Peak Load Net of DSM (MW)		2016	
Target Reliability Standard		0.1 days/year	
Target PRM		20%	
Total Requirement (MW)		**2,419**	
Resources	**Nameplate MW**	**Net Capacity (MW)**	**ELCC %**
Coal	1081	1081	100%
Oil	231	231	100%
Natural Gas/Heavy Fuel Oil	462	462	100%
Biomass/Biogas	76	76	100%
Run-of-River Hydro	162	162	100%
Wreck Cove Hydro	212	212	100%
Annapolis Tidal	19	3.5	18%
Feed-in-Tariff Tidal	6.5	1.3	20%
Wind	596	101	17%
Solar	1.7	0	0%
New COMFIT Renewables	179.1	16.3	9%
Maritime Link Base Energy Imports	153	153	100%
Total Supply (MW)	**3,179**	**2,499**	

Key Nova Scotia Challenges

Portfolio Optimization

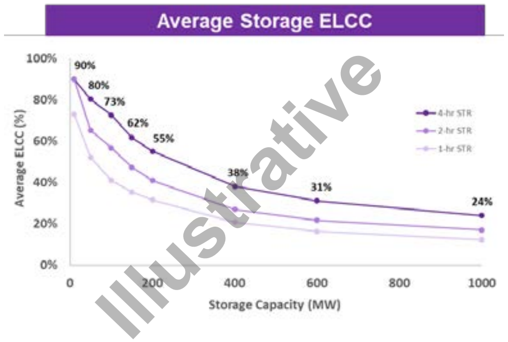
Determining the optimal portfolio of renewable, hydro, storage, thermal, and demand-side resources

All resources have limitations and unique characteristics and a least-cost portfolio reflects this



Firm Capacity

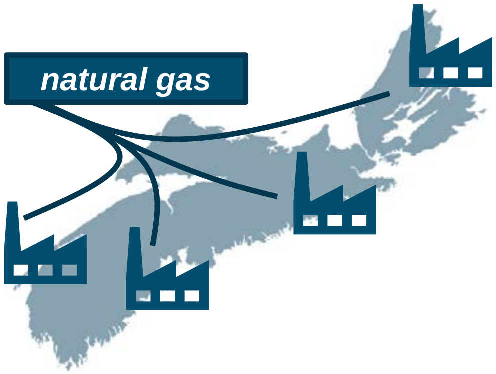
Maintaining adequate firm capacity for reliability considering potential coal retirements and the limitations of non-thermal resources



Firm Fuel

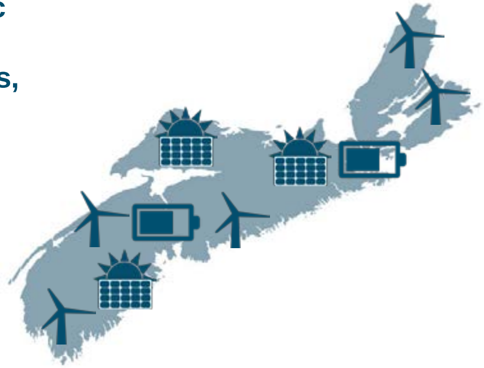
Ensuring firm fuel for new thermal resources despite limited pipeline capacity to Nova Scotia

Peak electricity loads correlate with peak natural gas demand for heating which constrains pipeline availability



Renewable Integration

Given the limited electric interconnections with neighboring jurisdictions, ensuring that higher penetrations of renewable energy maintains system stability, inertia, and other essential grid services



Energy+Environmental Economics

Thank You

Energy and Environmental Economics, Inc. (E3)

44 Montgomery St., Suite 1500

San Francisco, CA 94104

(415) 391-5100

ethree.com

Zach Ming, Sr. Managing Consultant (zachary.ming@ethree.com)

Arne Olson, Sr. Partner (arne@ethree.com)