Background

As the resource portfolio in the Western Interconnection transitions to more non-dispatchable, renewable resources, maintaining generation and load balance will continue to be one of the greatest challenges facing system operators. Energy storage is the concept of storing energy produced at one time for use at a later time to reduce imbalances between demand and production, typically during times when renewable generation is not available.

In this technical session, industry experts from Kaua‘i Island Utility Cooperative (KIUC), California ISO, and Los Angeles Department of Water and Power (LADWP) will discuss various energy storage technologies, integration challenges, and how energy storage can be used to maintain system reliability.

The following links to industry publications, websites, and NERC references provide some background on energy storage technologies and the unique challenges facing utilities as they prepare to meet aggressive clean energy targets:

- California Energy Storage Alliance (CESA)—Long-Duration Energy Storage Solutions
- Long-duration storage roundup: News, players and technology
- Kaua‘i Island Utility Cooperative (kiuc.coop)—Renewables

Speakers at this technical session include:

Cameron Kruse, Engineering and Technology Manager, KIUC

Cameron received his B.S. in electrical engineering from the University of Arizona in 2008. Upon graduation, he started working at KIUC as a staff engineer in Transmission and Distribution. He was promoted to supervise operations on the island’s electrical substations in 2011, and in 2020 he was promoted to Engineering and Technology Manager. During his time at KIUC, he has worked toward transforming the grid’s renewable generation from 8% to 67% in 2020.
Dede Subakti, Vice President, System Operations, California ISO

Dede Subakti currently serves as Vice President, System Operations in California ISO. He is responsible for all aspect of system operations from bid to bill. This includes new resources implementation process, operational readiness, day-to-day control room operations, all the way to settlement and dispute processes.

Dede joined the California ISO in 2010, serving first as Manager for Operations Planning. In 2012, he was promoted to his most recent position as Director of Operations for Engineering Services, in which he was responsible for operational engineering and support functions, including resource adequacy assessments, seasonal operating and outage coordination studies, and operating and reliability analyses.

He also supported the onboarding and day-to-day operations engineering for the Western Energy Imbalance Market (EIM), and RC West, the ISO’s reliability coordinator function for Balancing Authorities and Transmission Operators in the Western Interconnection.

Prior to joining the ISO, Subakti worked with Open Access Technology International (OATI), Inc., a global energy solutions and software company, managing project development for various transmission system applications for transmission service providers in both the Western and Eastern Interconnections. Before that, he served as Manager of Regional Operations Engineering at the Midwest ISO (now Midcontinent ISO) where he managed real-time operations engineers providing control room operations support. Subakti also has worked with representatives of the NERC and WECC to develop Reliability Standards and support the operation of the Western Interconnection.

He is a licensed professional engineer in Minnesota and a certified NERC System Operator. Subakti received a master’s degree in business administration from the University of Minnesota and a master’s degree in electrical engineering from Iowa State University, with an emphasis in power systems. He received his bachelor’s degree in electrical engineering from Iowa State University.

Greg Huynh, Intermountain Power Project’s Operating Agent Manager, LADWP

Greg serves as the Intermountain Power Project’s Operating Agent Manager where he and his team are working on transitioning the existing coal-fired project into a hybrid, hydrogen-natural gas facility with the eventual goal of transforming the power plant to a 100% green hydrogen, clean energy resource. Greg also led the team that spearheaded LADWP’s efforts to conduct a comprehensive study of how the City of Los Angeles can get to 100% Renewable Energy. He has been with LADWP for over 13 years and has worked in various parts of the Department; ranging from project management, power plant operations, and power planning.
Kauai Statistics

• 72,000 resident population (5% of State)
• Consistent visitor load (+28,000)
• 550 sq mi (10% of State)
• Member-owned Electric Cooperative
• High rates due to oil-dominated power supply (31-37 cents/kWh last 3 years)
• Low residential energy use due to stable climate (500 kWh per month avg)
KIUC Grid Statistics

- Completely islanded, vertically integrated
- 171 miles 69 kV-rated transmission
- 1,311 miles 12.47 kV distribution
- 35-80 MW daily demand profile
- 80 MW all-time peak (Aug 2019)
- 117 MW oil-fired generation capacity
- 106 MW solar (40% MW customer-owned)
- 16 MW hydro
- 7 MW biomass
- 58 MW / 240 MWh Battery Energy Storage
Hawaii State RE Mandate

Became law in June 2015:
• 30% by 2020
• 40% by 2030
• 70% by 2040
• 100% by 2045

In Hawaii, a coalition of environmental advocates and the solar industry pushed the passage of a bill requiring 100% renewable energy by 2045.
Background: Where Kaua‘i Gets Its Power

- **2009**: 91% Fossil Fuel, 9% Solar
- **2020**: 40% Fossil Fuel, 35% Solar, 14% Biomass, 11% Hydro
- **2025**: 24% Fossil Fuel, 49% Solar, 11% Biomass, 16% Hydro

Legend: Fossil Fuel, Solar, Biomass, Hydro
Kaua‘i’s Renewable Generation Sources

In development:
- West Kaua‘i Energy Project
- AES PMRF Solar plus Storage
- KAA Hydro
- Pioneer Solar
- Gay & Robinson Hydro
- McBryde Solar, Port Allen

KiUC Anahola Solar
- Kapa‘a Solar
- KiUC Waiahi Hydro
- Tesla Solar plus Storage
- Green Energy Team
- MP2 Solar
- KiUC Kōloa Solar
- AES Lāwai Solar plus Storage
- McBryde Hydro, Kalāheo
Renewable Use Cases

• Energy dispatch to offset the use of traditional diesel engines
  • PV shifting with BESS
  • 1 second setpoint dispatch
• Fast Frequency Droop Response (P, Q)
  • <50ms response
• Voltage regulation via 24/7 Var setpoint
• Grid Forming
Technical Session Meeting Book - Technical Session - The Impact of Energy Storage on System Reliability

Daily Dispatch
Fast Frequency Droop Response Leads to Steady State Oscillations
Fast Frequency Droop Response
Kaua‘i’s Renewable Generation Sources

In development:
- West Kaua‘i Energy Project
- AES PMRF Solar plus Storage
- KAA Hydro
- Pioneer Solar
- Gay & Robinson Hydro
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[Map of Kaua‘i with various renewable energy sources marked on it]
In development:

West Kaua‘i Energy Project

AES PMRF Solar plus Storage

KAA Hydro
West Kaua`i Energy Project (WKEP)

• 35MW PV DC – 35MW / 70 MWh BESS
• 35MW of pumping capacity (37,800 fluid horsepower)
• Allow for longer duration storage (10-12 hours)
• 20MW + 4MW hydro
• 25% of energy for the island
WKEP – Reliability Benefits

• Pumping can happen in microgrid
• When grid connected, pumps can be incorporated into UFLS in stages
• When pumping, 20MW hydro can run in synchronous condensing mode for voltage stability and short circuit current
• Black start capability via grid forming inverters
• BESS offers fast frequency response (<50ms)
Lessons Learned

• Synchronous Generation in parallel with Renewable Sources should be tuned to prevent steady state oscillations
• Fast Frequency Response from inverters should be tuned to prevent out of band frequency conditions
• High speed recorders have been a great tool for transient responses
Thank you

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Integration of Energy Storage in California ISO

Dede Subakti, P. E.
Vice President, System Operations

September 8, 2021
Agenda

• Introduction
• Evolution of energy storage in California ISO
• Observation of energy storage usage and behavior
California ISO - Introduction

Evolution of energy storage in California ISO

• Prior to 2010:
  – In CAISO, primary energy storage was pump-hydro

• By end of 2020 and beginning of 2021:
  – CAISO has approximately 500 MW of Battery Energy Storage Systems (BESS)

• By August 2021:
  – CAISO has approximately 1,500 MW BESS

• By end of 2021:
  – CAISO is expecting approximately 3,000 MW BESS
Observation of Energy Storage usage and behavior

Prior to 2010: Energy is stored during the night and used during the day

Example of Pump Storage Behavior
Observation of Energy Storage usage and behavior

High penetration of solar has changed the utilization of energy storage

Example of Pump Storage Behavior
BESS usage and behavior in the beginning 2021

Typical behavior observed when storage penetration was lower at the beginning of 2021 (BESS ~ 500MW)
BESS usage and behavior in Summer 2021

Typical behavior observed when storage penetration was higher in the summer of 2021 (BESS ~ 1500MW)
BESS usage and behavior in Summer 2021

Typical interaction between solar and battery in a summer day in CAISO reflect both utilization for regulation and energy need.
Storage resources shifted energy from low priced periods to the evening peak

- Observation of “State of Charge (SOC)” for BESS in CAISO
- BESS need to be optimized and positioned to have the correct SOC to meet the need of the grid.
Energy storage capacity in ISO queue

- 49 percent standalone
- 51 percent hybrid

Graph showing project MW from Jun 2014 to Jun 2020, with categories for Compressed Air, Flywheel, Rail Gravity, Molten Salt, Pumped Storage, and Battery.
Questions/Comments

Dede Subakti, P. E.
Vice President, System Operations

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Intermountain Power Project
September 2021
CURRENT INTERMOUNTAIN POWER PROJECT

• LOCATION: DELTA, UTAH
• OWNED BY THE INTERMOUNTAIN POWER AGENCY (IPA)
• 35 PROJECT PARTICIPANTS (23 UTAH AND 6 CALIFORNIA MUNIS, 6 UTAH COOPS)
• TWO COAL UNITS – 1,800 MW NET CAPACITY
• NORTHERN AND SOUTHERN TRANSMISSION SYSTEMS
• CURRENT LADWP WIND INTERCONNECTIONS
  o MILFORD WIND: 287 MW
  o PLEASANT VALLEY: 82 MW
• COAL CLOSURE BY 2025
• LADWP IS THE PROJECT MANAGER AND OPERATING AGENT
• Coal units will be replaced by two combined-cycle power generation trains totaling 840 MW
• Provides dispatchable energy required to maintain reliability and support HVDC transmission
• Units capable of integrating with renewable resource variability
• DC Converter stations to be replaced
• Needed to meet LADWP’s 100% Renewable Goals
Unlocking IPP’s Green Hydrogen Potential

RENEWABLES
TRANSMISSION
LAND & WATER
SALT DOME
PEOPLE
Utah’s Renewable Hub

• IPP sits in a confluence of renewable resources
• Currently interconnected about 400 MW of wind generation and geothermal
• 2,300 MW of current solar interconnection requests in queue
• 1,500 MW of Wyoming wind interconnects currently being discussed
• Considered the “Western Renewable Energy Hub”
Green Hydrogen Future

The hydrogen pathway at IPP represents a first-of-its-kind opportunity for the western energy grid. Utilizing its existing transmission capabilities to power hydrogen-generating electrolyzers, the fuel can be either stored in the massive geologic salt formation or burned in the existing combustion generators.

- **Renewables**
  - Solar and wind resources from Wyoming, Utah, Nevada, and California
  - NTS and STS required for transmission

- **Electrolysis**
  - Using renewable energy, electrolyzers change water into hydrogen gas

- **Storage**
  - Hydrogen fuel is stored in underground salt caverns
  - Allows for seasonal shifting on renewable energy

- **Combustion**
  - Combustion technology is capable of mixing hydrogen with natural gas
  - New IPP generators will have this capability at 30% on COD
Generator Upgrades

• Mitsubishi Power has committed to performance requirements to allow 30% hydrogen fueled units for 2025

• This upgrade could be achieved with modest modifications during regular planned maintenance outage

• Focused on safety and developing protocol for stable operations
Future Proofing for H2

- What’s needed to get to 100%
  - Combustor technology development
  - Modifications to Balance of Plant equipment
  - Infrastructure to support 100% Hydrogen

- What we’re doing today
  - Plant layout designed for installation of future H2 equipment
  - Installation of flexible green H2 and natural gas fuel mixing systems
  - Designing the systems to lower the life cycle costs of transition to 100% H2
Hydrogen Storage at IPP

Hydrogen storage is one of IPP’s most unique features.

Allows for SEASONAL SHIFTING of renewable energy; taking the otherwise curtailed energy and storing it as fuel.

- A typical cavern size at IPP = 4,000,000 barrels
- 1 cavern = 5,512 tons of H₂ (operational limit)
- Equivalent to:
  - 200,000 hydrogen buses
  - 1,000,000 fuel cell cars
  - 14,000 tube trailers used for delivery
- Over 100 caverns can be constructed in the salt dome near IPP
Need for Multi Day and Seasonal Energy Storage

California 100% renewable scenario: Daily net energy demand

- Winter deficit
- Multi-day weather events/energy deficits
- Seasonal energy deficits
- Spring/summer surplus
- Autumn/winter deficit

Source: CAISO and Strategen Analysis
Energy Storage Potential

STORAGE IN ONE CAVERNS AT IPP IS 84 TIMES THE STORAGE CAPACITY OF THE 1,200 MWH ELAND BATTERY SYSTEM
Electrolyzer Costs Expected to Drop

- Electrolyzers are a major cost driver in value chain
- Forecasts show that the prices are expected to significantly decrease with time
- Lines up with Generator upgrades for additional volumes of H2.

Source: BloombergNEF. Note: Assumes system size of 4MW in all years.
Hydrogen Timeline

- **2022**
  - NGCC Construction Start
  - IPP Coal Units Retired
  - NGCC Online

- **2025**
  - 55% RPS Target

- **2026**
  - IPP Switchyard Upgrade

- **2028**
  - 1000-1500 MW Wind Interconnection at IPP

- **2030**
  - 60% RPS Target

- **2032**
  - 1st Unit Major - Hydrogen Upgrade

- **2034**
  - 80% RPS Target

- **2036**
  - 2nd Unit Major - 100% Hydrogen Upgrade

- **2040**
  - NGCC Major Overhaul Updates w/ Latest Hydrogen Capability

- **2042**

- **2044**

- **2045**
  - SB100 Mandate - 100% Clean Energy
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Los Angeles Department of Water & Power  
Intermountain Power Agency  
Energy for Today & Tomorrow