Integrated Grid Planning

Resilience Working Group Meeting

November 22, 2019

WELCOME AND OPENING REMARKS

Housekeeping

- Restrooms – Code: **3698**
- Emergency exits
- Parking validation

Recap of Previous Meeting

PURPOSE

- Identify threat impacts to grid and key customers
- Develop inputs to Integrated Grid Planning
- Identify grid resilience planning criteria

LESSONS LEARNED

- Utilities moving toward acquiring clean energy
- Resilience criteria may include recovery time for key customers and other customers
- Consider rain bombs as another serious threat

PROCESS OVERVIEW

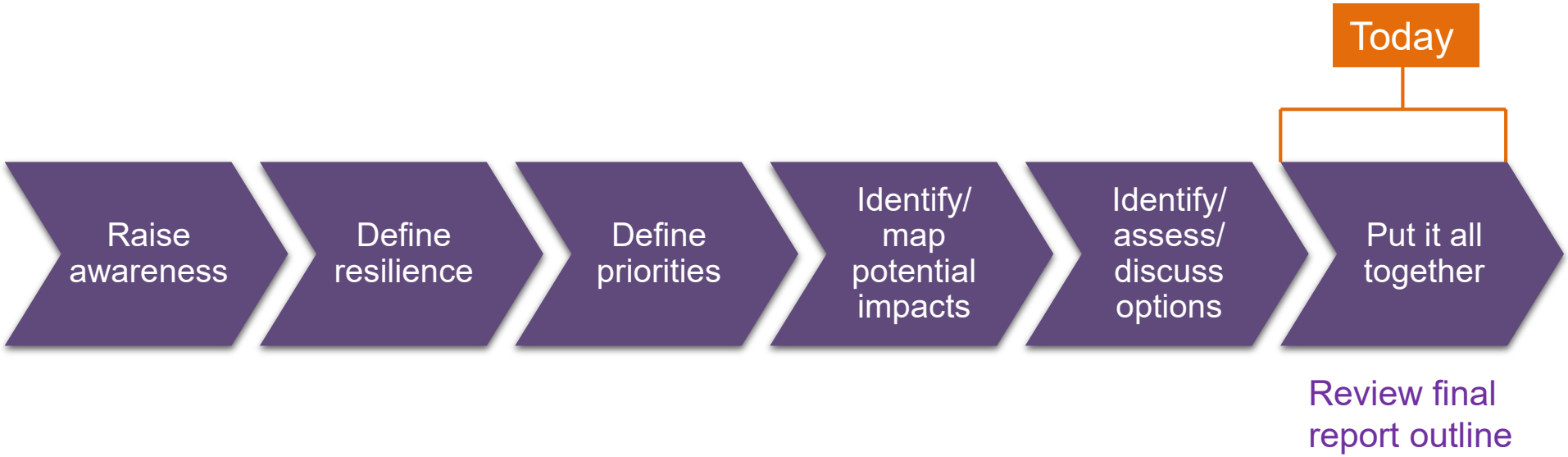
1. Raise awareness
2. Define resilience
3. Define priorities
4. Identify potential impacts
5. Identify/assess options
6. Put it all together

Topics Covered

1. Mapping of customers to threats and grid
2. Assumptions regarding threat impacts and outages
3. Inputs to IGP: objectives, assumptions, threat scenarios, resilience criteria, and solution options

OVERVIEW AND PLAN FOR THE DAY

IGP RWG Process Overview



Meeting Objectives

1

Review and comment on draft outline of RWG report

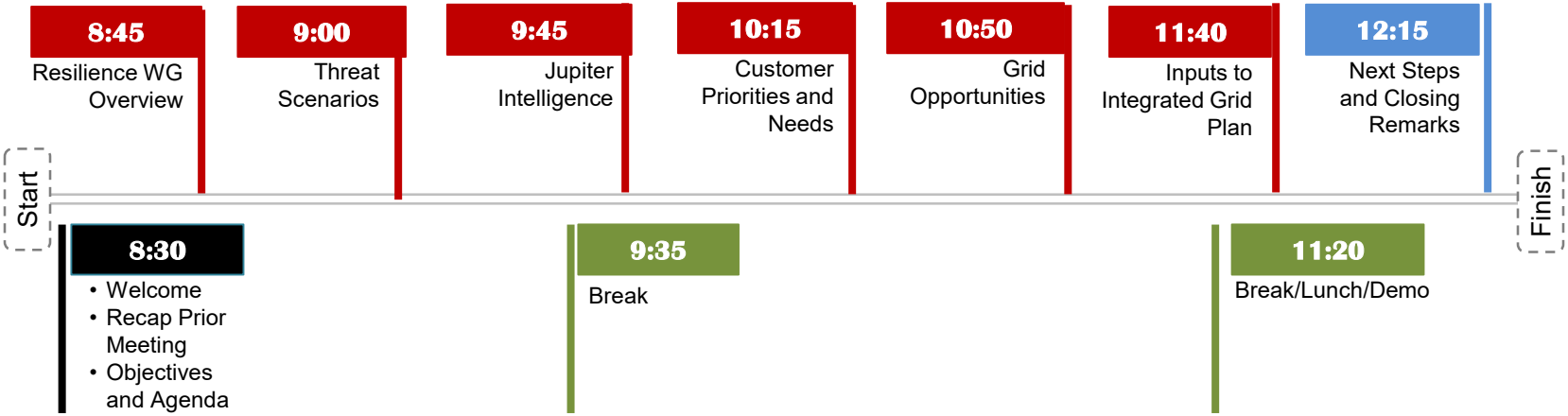
- Definition of resilience
- Resilience threats and impacts to grid and customers
- Key customer/sector capabilities and needs

2

Review and comment on Integrated Grid Planning inputs

- Resilience objectives and measurement criteria
- Assumptions and threat scenarios
- Resilience strategies

Meeting Agenda

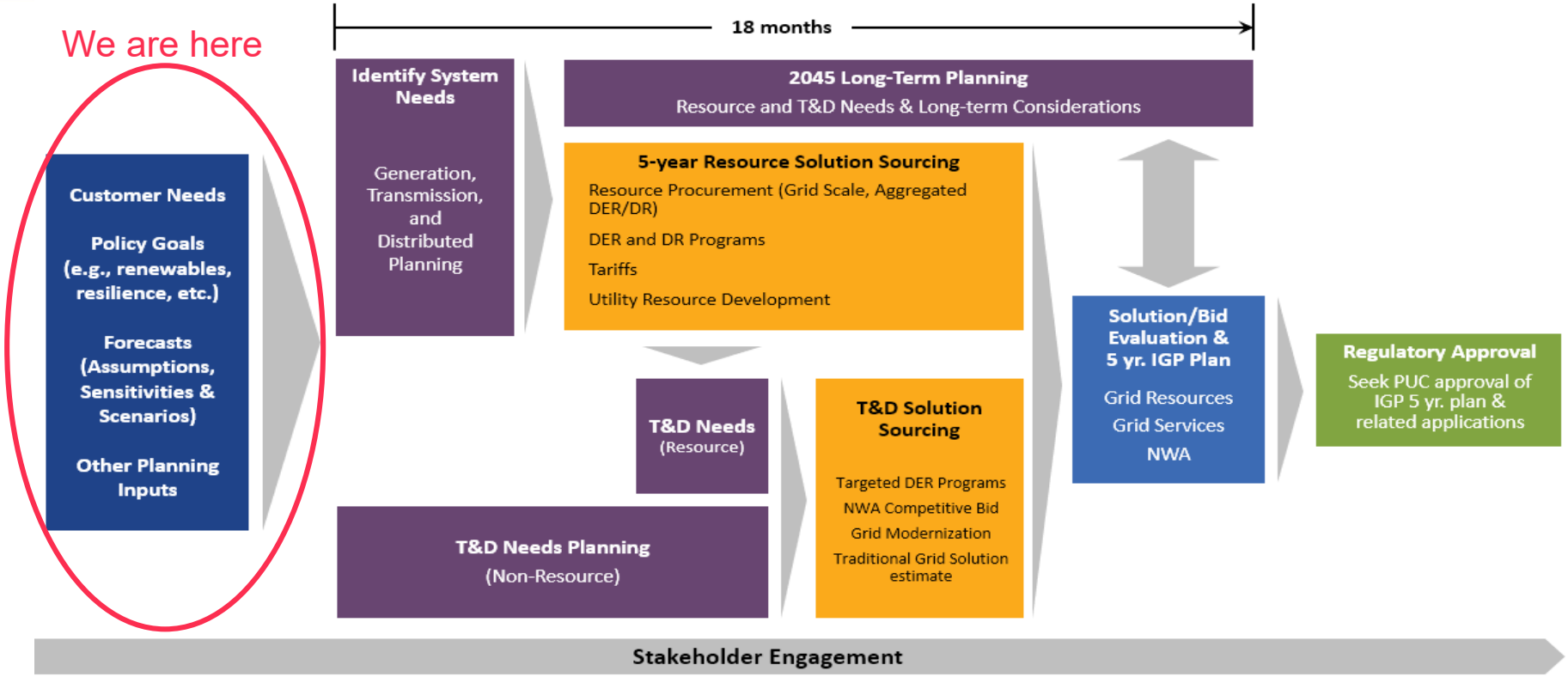


Handouts

- Agenda/Chatham House Rules
- Schedule of Resilience Working Group meetings
- Topical outline of final report
- List of organizations and individuals on RWG for inclusion in final report

RESILIENCE WORKING GROUP OVERVIEW

Overview of Integrated Planning



Stakeholder Engagement in Integrated Planning

Working Groups

Affordability

- Standard Contract
- Competitive Procurement

Reliability

- Forecasts and Assumptions
- Distribution Planning
- Resilience

Energy Choices

- Grid Services
- Solution Evaluation and Optimization

Resilience Working Group Role

Support the development of resilience planning criteria for Hawaii's power system including resource, transmission and distribution, in relation to potential societal and economic impacts.

- Identify and prioritize resilience threat scenarios and potential grid impacts
- Identify key customer/infrastructure sector capabilities and needs following a severe event and loss of power
- Identify gaps and priorities in grid and customer capabilities following a severe event and loss of power
- Provide recommendations and inputs for integrated grid planning to address resilience needs
- Recommend additional grid and customer actions to close gaps in capabilities following severe events

Resilience Working Group Meetings

- July 22, 2019
  - Introduce Resilience Working Group topics and get initial input/thoughts
- August 29, 2019
  - Review needs and existing capabilities of critical infrastructure/customer segments under a severe hurricane scenario
  - Get preliminary consensus on resilience process
- September 17, 2019
  - Define severe event priorities
  - Identify/map potential impacts of all hazards
  - Identify/assess/discuss mitigation options
- October 28, 2019
  - Mapping of threats, vulnerabilities, key customer needs and capabilities as compared to grid
  - Review planning criteria/scenarios
- November 22, 2019
  - Review outline of final report
- December 16, 2019
  - Review final written report
  - 4 week RWG review and comment period through January 10
  - Consensus/acceptance by RWG
  - Consider minority views

Resilience Working Group Membership

FEMA

Board of Water Supply
City and County of Honolulu

Department of Environmental Services

Hawaii County Civil Defense Agency

blue planet FOUNDATION

Energy Freedom Coalition of America

ulupono INITIATIVE

HSEA HAWAII SOLAR ENERGY ASSOCIATION

Progression HI Offshore Wind

Energy Island

Hawai'i PV Coalition

County of Hawaii

Life of the Land

REACH

Par Hawaii

Spectrum

verizon wireless

Hawaiian Telcom

Chamber of Commerce HAWAII
The Voice of Business

HAWAII STATE Energy Office

State of Hawaii Office of Planning

DEPARTMENT OF DEFENSE

Hawaii Emergency Management Agency

Department of Transportation

STATE OF HAWAII
PUBLIC UTILITIES COMMISSION

Defining Resilience

- "Resilience is the ability of a system or its components to adapt to changing conditions and withstand and rapidly recover from disruptions. " – PUC Staff, PBR Docket
- Key elements
  - Ability to minimize impacts of severe events
  - Ability to sustain mission critical functions under severe conditions
  - Ability to rapidly recover from a severe event
  - Ability to learn from severe events and continuously adapt

Discussion Questions
Role of RWG and Definition of Resilience

1. Is the Integrated Planning Process sufficiently understood, particularly stakeholder and RWG roles?
2. Are the goals and objectives of the Resilience Working Group understood and acceptable to the RWG?
3. Are there any concerns with the final report review and acceptance process or outline of the final report?
4. Are the definition of grid resilience and description of the elements of resilience acceptable to the group?

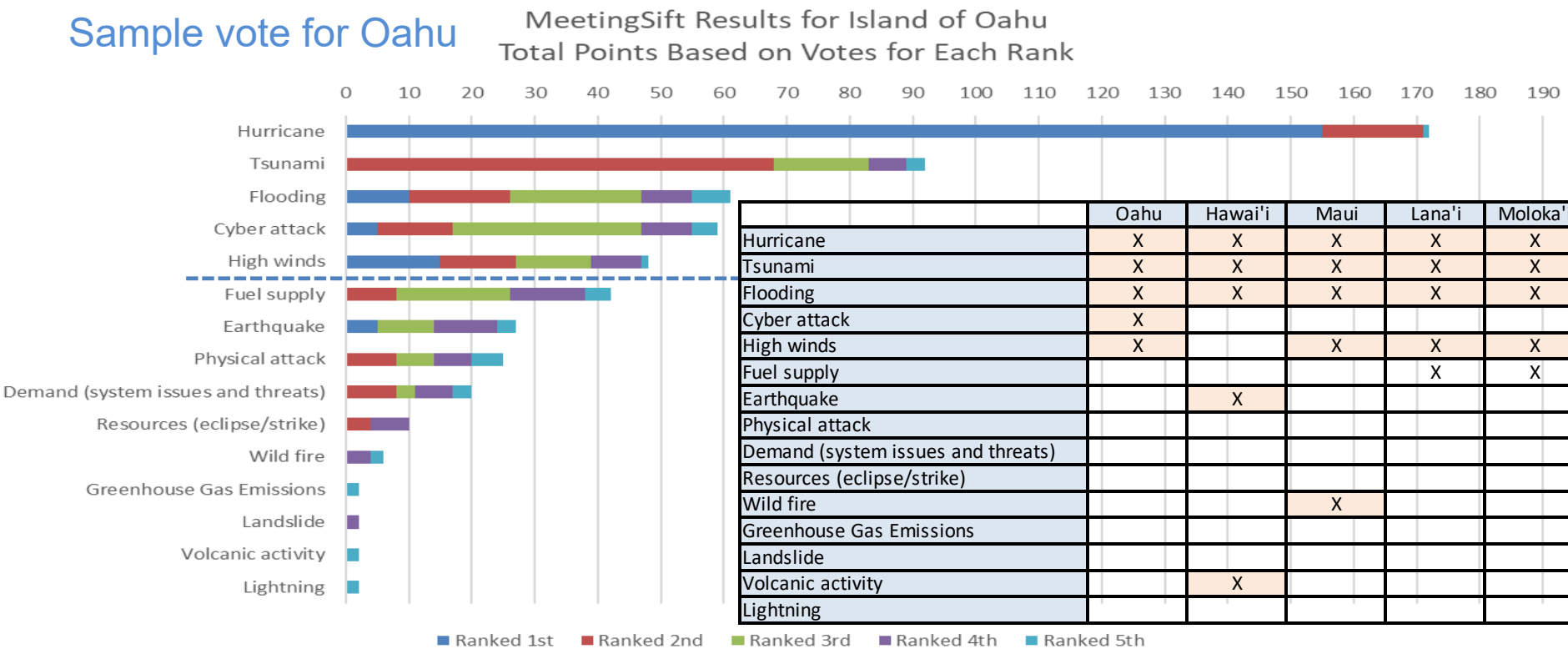
RESILIENCE THREAT SCENARIOS

Historical Perspective: Severe Events Affect Hawai'i

- Hurricanes (more than 3 dozen threats since 2000)
  - Iniki – Category 4 hit Kaua'i September 11, 1992
  - Iwa – Category 1 hit Oahu and Kaua'i November 23, 1982
- Flash floods/rain bombs
  - April 2018 areas over 50 inches of rain in 24 hours (2nd most in U.S. history after Harvey)
  - March 2006 – 30 days of torrential rain
  - January 2001, October 2004, December 2008 – torrential rain and flash floods
- Tsunamis
  - April 1, 1946, 7.8 earthquake off Aleutian Islands caused tsunami max 55 feet runup
  - 5/22/60 Valdivia 9.5 earthquake in Chile caused tsunami in Hawai'i
  - 3/11/11 state emergency for tsunami
- Earthquakes
  - 4/2/1868 7.9 magnitude on Hawai'i Island
  - 10/15/06 6.7 magnitude on Hawai'i Island
- Volcano
  - Kilauea erupting since 1983

RWG Ranking of Threat Scenarios – Top 5 by Island

Sample vote for Oahu



	Oahu	Hawai'i	Maui	Lana'i	Moloka'i
Hurricane	X	X	X	X	X
Tsunami	X	X	X	X	X
Flooding	X	X	X	X	X
Cyber attack	X				
High winds	X		X	X	X
Fuel supply				X	X
Earthquake		X			
Physical attack					
Demand (system issues and threats)					
Resources (eclipse/strike)					
Wild fire			X		
Greenhouse Gas Emissions					
Landslide					
Volcanic activity		X			
Lightning					

Severe Events Considered and Prioritized by RWG

Natural	C	P	Technological	C	P	Attack	C	P
Avalanche			Dam failure			Physical (shooter)	X	X
Drought			HazMat			Physical (explosive)	X	X
Earthquake	X	X	Industrial Acc			Cyber	X	X
Epidemic			Levee failure			Chemical		
Flood	X	X	Mine Accident			Improvised nuke		
Hurricane	X	X	Pipeline			Terrorist nuke		
High wind	X	X	Radiological			Radiological		
Space weather			Train Derail					
Tornado			Transportation					
Tsunami	X	X	Urban fire					
Volcano	X	X	Utility outage					
Wildfire	X	X	Fuel supply	X				
Landslides	X		Demand/resources	X				
Greenhouse gas	X					C - Considered		
Lightning	X					P - Prioritized		

Threat Scenarios Consolidated for Input to Integrated Planning

September Meeting

Threat	Includes	Oahu	Hawai'i	Maui	Moloka'i	Lana'i
Hurricane	Flood, Wind	X	X	X	X	X
Tsunami	Earthquake	X	X	X	X	X
Fuel Disruption		X	X	X	X	X
Wild Fire				X	X	X
Cyber Attack		X		X		
Physical Attack		X				
Volcano			X			

October Meeting

Threat	Includes	Oahu	Hawai'i	Maui County
Hurricane	Flood, Wind	X	X	X
Tsunami	Earthquake	X	X	X
Wild Fire		X		X
Physical Attack	Cyber Attack	X	X	X
Volcano			X	

- 12 threat scenarios for study, 4 per county
- Moderate + severe conditions for each; volcano requires 1 scenario (23 total)
- High impact scenarios capturing damage to electric and key customer infrastructure
- Fuel supply is an issue for all scenarios with extended outage times
- Combined cyber and physical security into one hybrid threat

Hurricane Hazard Impact Areas
(All Locations on all Islands)

- Depending on path of hurricane, all islands and locations can be subject to damaging wind, rain and coastal and inland flooding
- Sample impacts
  - Category 2: 96-110 mph wind; 6-8’ surge; power lines/poles damaged
  - Category 4: 130-156 mph wind; 13-18’ surge; most trees broken or toppled; damage to majority of power lines and poles; some damage to substations and power plants

Coastal Flooding Impact Areas

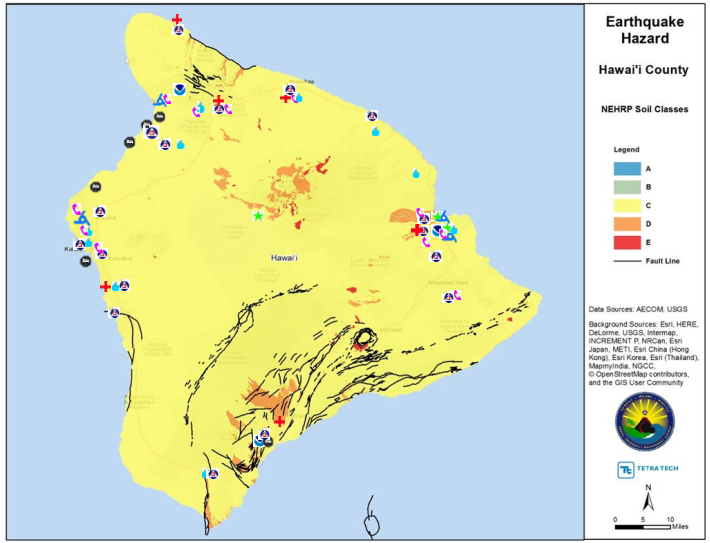
- Severe coastal flooding in Oahu along south and north
- Flooding of key customers and backup generators in coastal areas
- Flooding of utility distribution substations and lines in coastal areas
- More limited coastal flood impacts in Hawai'i and Maui County

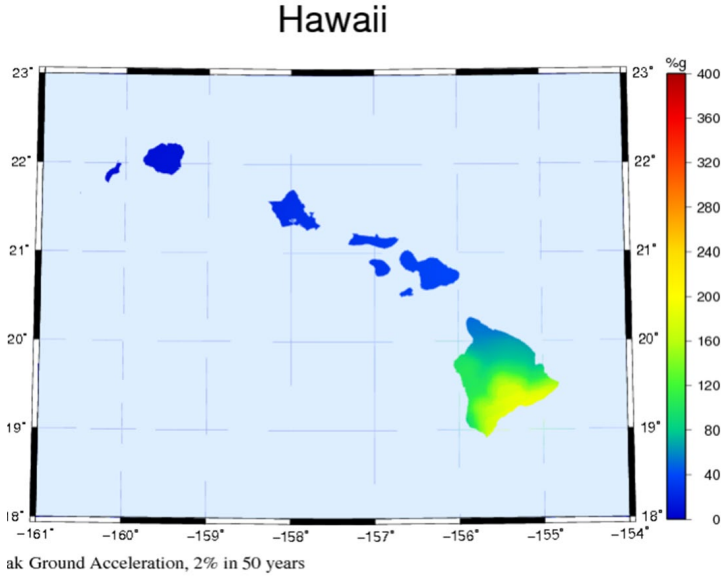
Threat Scenario: Hurricane, Wind, Flood
O'ahu, Hawai'i Island, and Maui County

- Moderate
  - Category 2
  - 96-110 mph winds
  - 10 foot storm surge
  - Coastal infrastructure damage
  - Damage to distribution lines and poles due to wind, falling trees/branches, and flying debris
  - 5-8% of transmission circuits have sustained outage and restored in 3-7 days
  - 20-30% of distribution circuits out and restored in 1-4 weeks
  - Roads cleared 3-4 days
  - Fuel supply available within 3-4 days
- Severe
  - Category 4
  - 130-156 mph winds
  - 20' storm surge
  - Coastal infrastructure destroyed
  - Damage to transmission lines, poles and towers due to wind, falling trees/branches, and flying debris
  - 25-30% of transmission lines have sustained outage and restored over four months
  - 50-75% of distribution lines out of service and restored over four months
  - Fuel resupply available after four weeks

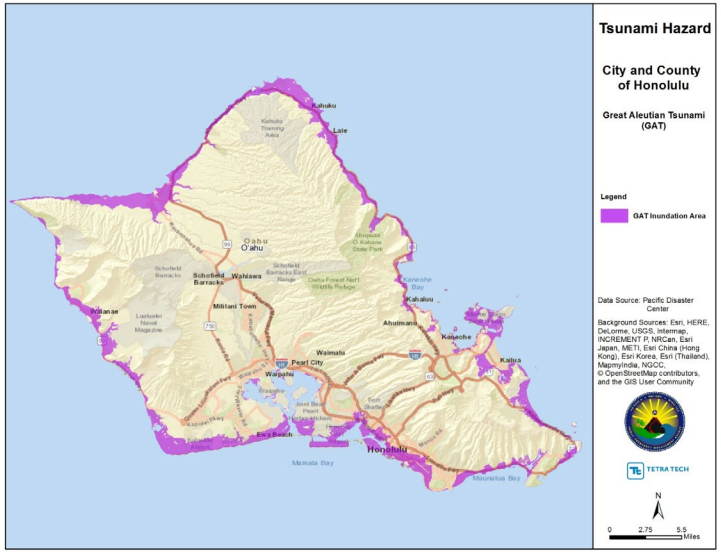
Earthquake Impact Areas

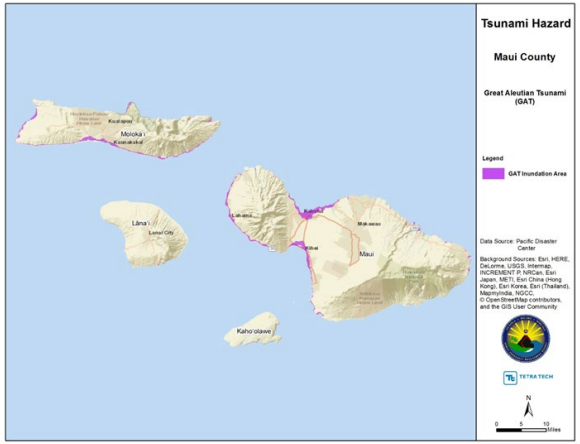
- Highest risk for Hawai'i Island
- Major fault lines on east portion of island near Hilo and critical infrastructure
- Seismic damage is a risk but much lower impacts on remaining islands

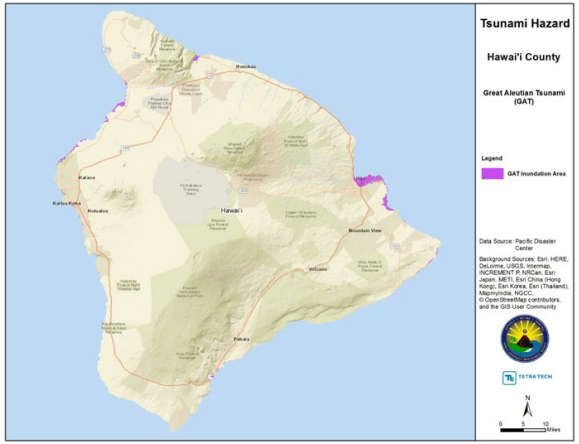




Tsunami Impact Areas







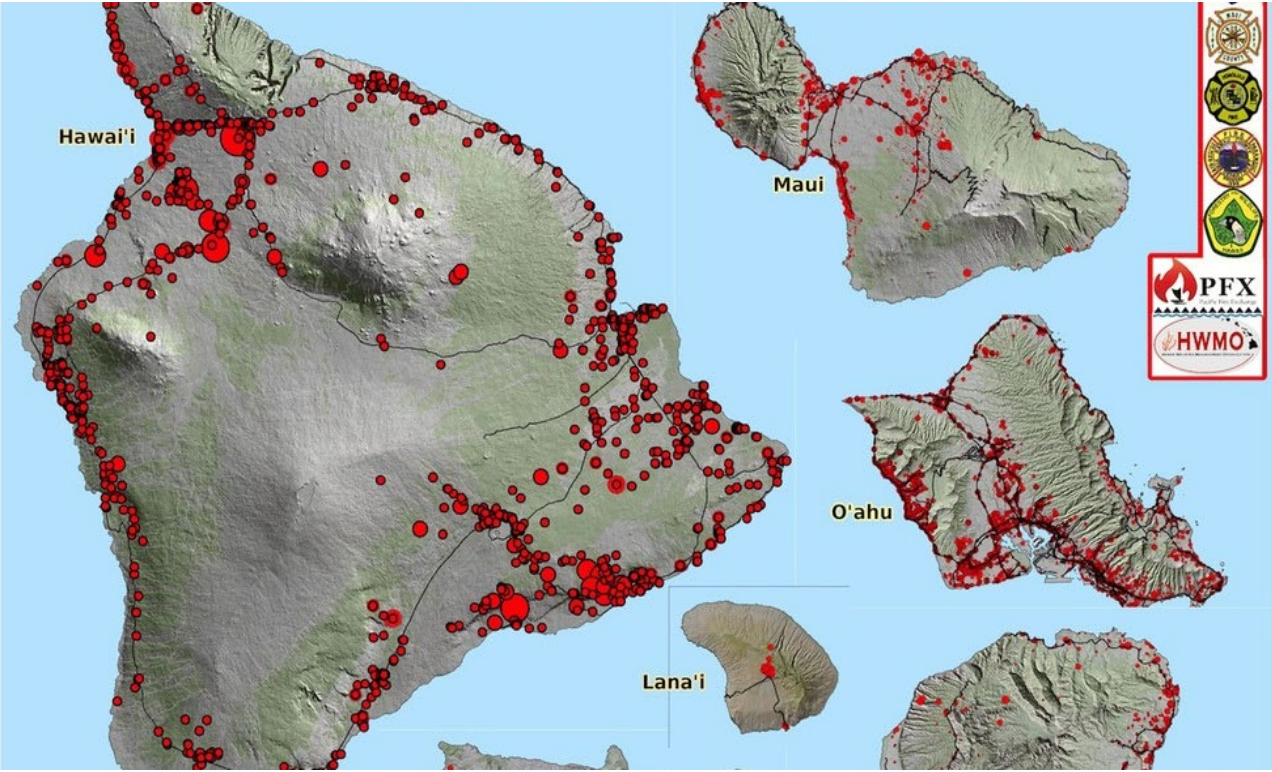
- Tsunami infrastructure risk highest in Oahu
- Significant damage to utility and customer infrastructure along coastal areas
- Some coastal infrastructure damage expected in Maui

Threat Scenario: Tsunami and Earthquake
O‘ahu, Hawai‘i Island, and Maui County

- Moderate
  - 6.5 earthquake on Hawai’i island
  - Infrastructure damage on eastern and southern portions of island including Hilo
  - Transmission and distribution lines and poles damaged
  - Restoration times 1 day to two weeks
- Severe
  - 8.5 earthquake near East Aleutian Islands
  - 50+ foot runup moving as far inland as 0.75 mile affecting all islands
  - Coastal distribution substations and feeders restored over one week to six months

Wildfire Impact Areas

- Wild fires can damage power lines and poles in fire prone areas
- Impact risks high in Oahu, Maui, Hawai'i Island and Moloka'i



Threat Scenario: Wild Fire
O'ahu and Maui County

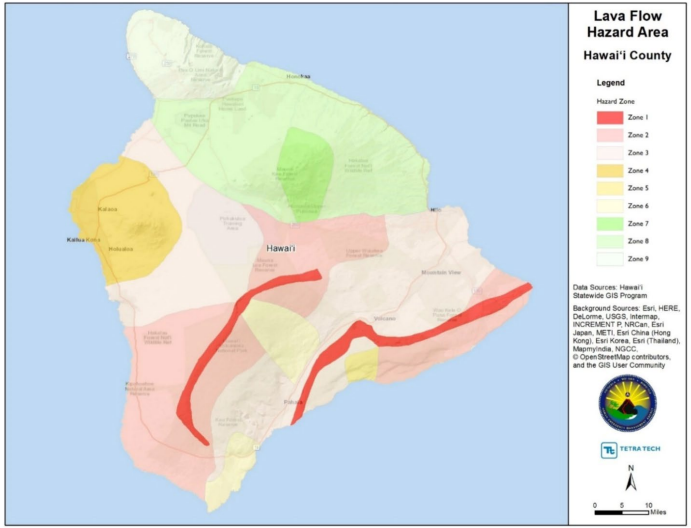
- Moderate
  - Massive wildfire on western slopes of Oahu damage all northern transmission corridor circuits
  - 25% of poles and towers sustain permanent damage
  - One line restored after 8 weeks; remaining lines restored over four months
- Severe
  - Severe wildfire destroys Maalaea power plant switchyard and power lines emanating from station
  - Reconstruction and repairs completed in six months

Threat Scenario: Physical/Cyber Attack
O'ahu, Hawai'i Island, and Maui County

- Moderate
  - Most critical substation sustains physical damage from high powered rifles and several explosive devices
  - Half of transformers at substation can be repaired within two weeks
  - Half of transformers at substation are permanently damaged and require 12-18 months for permanent replacement
  - Lines and switchgear can be repaired in two to six weeks
- Severe
  - Two most critical substations sustain physical damage from high powered rifles and several explosive devices
  - Half of transformers at those two stations can be repaired within two weeks
  - Half of transformers at the two stations are permanently damaged and require 12-18 months for permanent replacement
  - Lines and switchgear repaired in two to six weeks
  - Cyber attack disables control center situational awareness and primary voice communications for 24 hours

Threat Scenario: Volcano
Hawai‘i Island

- Severe
  - Mauna Loa experiences massive eruption including record lava flows and toxic gases through the south and central portions of the island
  - Severe activity continues for one month
  - Transmission outages include north-south corridor in east and east-west corridor splitting the loop
  - 27% of generation is located hazard zone and could be affected for years
  - Worker access limited due to conditions for one month



Discussion Questions
Selection of Threat Scenarios for IGP

1. Are the 12 threat scenarios (4 per county) a good set of events to challenge the grid and key customers?
2. Do the descriptions of the potential impacts of the severe events appear to reasonably describe future expectations?
3. Are the scenarios described sufficient and reasonable for evaluating grid resilience performance for the future?
4. What other comments do you have on what you heard?

JUPITER INTELLIGENCE

KEY CUSTOMER PRIORITIES AND NEEDS

Criteria for Identifying Customers/Sectors

Tier 1	Tier 2	Tier 3
Essential for national security and/or public safety and health	Important for national security, public safety and health, and other essential services	Remaining customers
Essential for power system restoration	Supports power system restoration	
Power should be restored within minutes up to several hours (by utility or backup resource)	Power should be restored within hours up to several days (by utility or backup resource)	

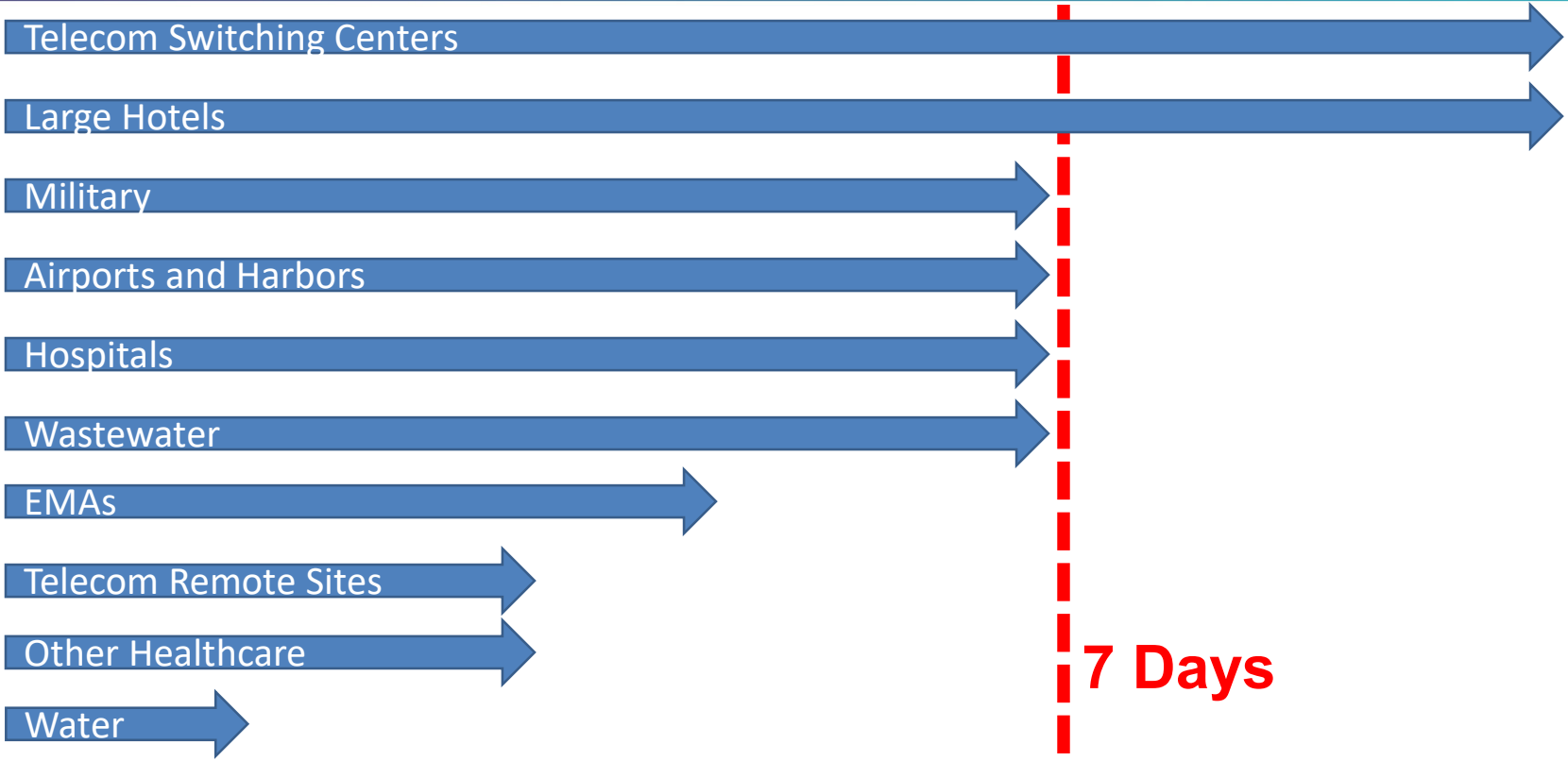
- Resilience objectives
  - Maintain critical functions
  - Limit fatalities and human suffering
  - Limit infrastructure damage
  - Limit property damage
  - Limit cost/economic impacts
  - Limit environmental impacts

Suggested Priorities for Customers/Sectors

Tier 1	Tier 2	Tier 3
• Military • Telecommunications • Hospitals and critical healthcare • Water and wastewater • Emergency management and first responders	• Transportation • Hospitality • Banking and finance	• Remaining customers

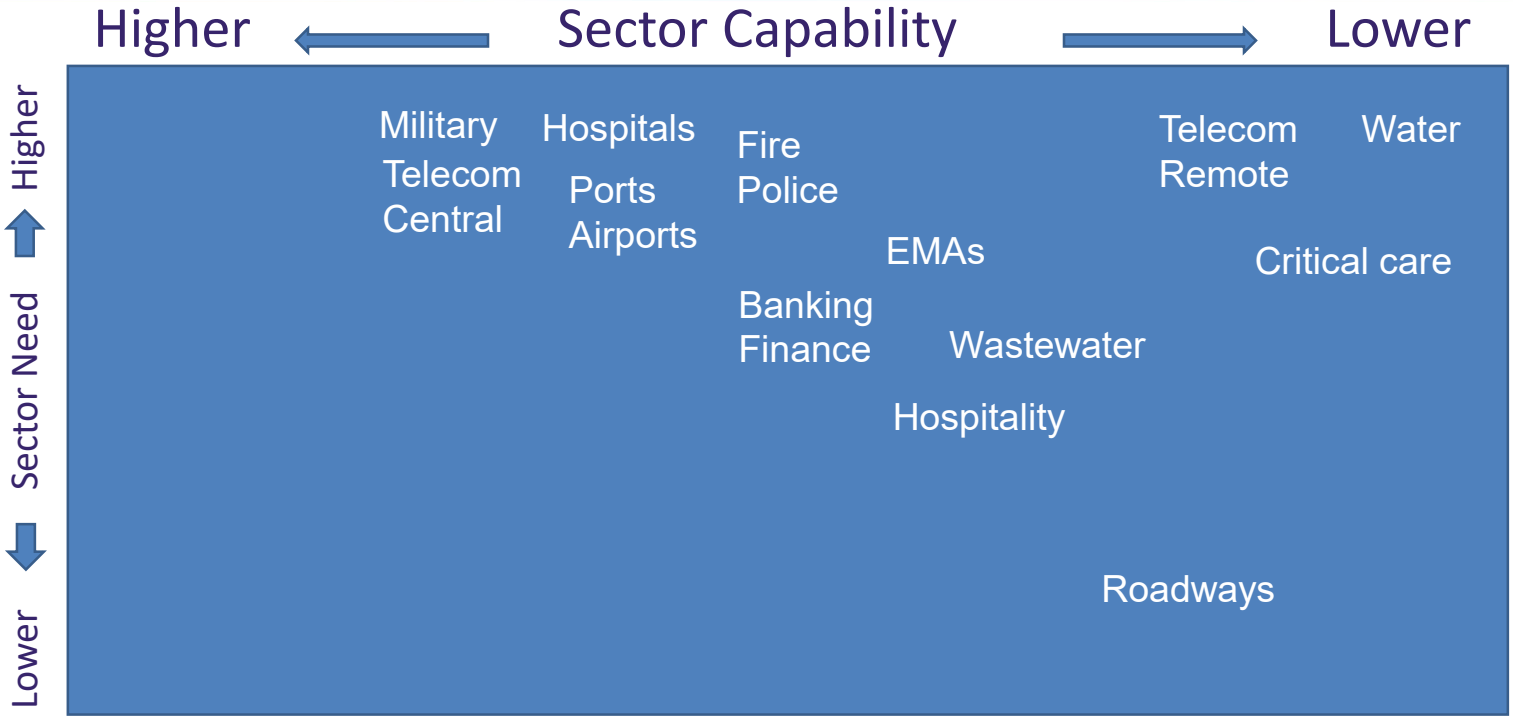
Summary of Backup Power and Fuel Capabilities

Interpreted from Breakout Notes August 29



Customer Sector Need vs Capability

Interpreted From Breakout Notes August Meeting



Even the most capable sectors are limited to 1 week or less without refueling

Sector Interdependencies

Electricity

- All sectors need power restored as soon as possible

Telecommunications

- All sectors need cell, landline, and data communications as soon as possible

Transportation

- Road access is critical to most other sectors
- Airports and ports critical for fuel and supplies for recovery

Water and wastewater

- All sectors require water and wastewater support

Banking and finance

- Required to pay employees and critical supplies

Emergency management, hospital, hospitality

- All sectors need housing facilities and healthcare

O‘ahu Island Critical Facilities

MAP REMOVED FOR CONFIDENTIALITY

- Concentrated in Honolulu and south shore
- Others distributed in central and shore areas
- Generation southwest with resources at Schofield and Honolulu
- Renewables distributed across island
- Transmission backbone west to east along south

Hawai‘i Island Critical Facilities

MAP REMOVED FOR CONFIDENTIALITY

- Concentrated in Hilo and Keahole
- Transmission ring with connectors across
- Power plants at Hilo and Keahole
- Renewables distributed in south and across island

Maui Island Critical Facilities

MAP REMOVED FOR CONFIDENTIALITY

- Generation at Maalaea and Kahului
- Critical customers in Kahului area and resorts along west coast

Lana‘i Island Critical Facilities

MAP REMOVED FOR CONFIDENTIALITY

- Central generation with radial distribution
- Limited critical customer sites

Moloka‘i Island Critical Facilities

MAP REMOVED FOR CONFIDENTIALITY

- Central generation with radial distribution
- Limited critical customer sites

Critical Customer/Sector Opportunities to Improve Resilience under Scenarios Identified

- Backup power supply at all critical sites
- Regular testing and operation of backup units
- Consider increasing fuel storage for backup units
- Consider alternative technologies for the most critical sites, including microgrid, renewable and storage, grid-forming inverters, other clean fuel black start units

Discussion Questions
Key Customer/Sector Priorities and Capabilities

1. Are the tiers an acceptable approach to prioritizing key customers, and are sectors shown in the correct tier?
2. Are resilience capabilities, including backup power supply and fuel resupply, described adequately?
3. Are the sector interdependencies described sufficiently? What else should be identified?
4. What actions should critical customers focus on to improve resilience under cited threats and extended power outages?

GRID OPPORTUNITIES TO IMPROVE RESILIENCE

Characteristics and Vulnerabilities of Existing Electricity Infrastructure – O‘ahu

MAP REMOVED FOR CONFIDENTIALITY

Characteristics

- More linear system
- Load concentration in Honolulu
- Generation concentration in one location

Major Vulnerabilities

- Transmission disruption
  - Towers and poles damaged
  - Difficult access in some areas
  - Limited spares
- Generation flooding
- Fuel disruption

Characteristics and Vulnerabilities of Existing Electricity Infrastructure – Hawai‘i Island

MAP REMOVED FOR CONFIDENTIALITY

Characteristics

- Ring system with cross ties
- Load center and key loads
  - Hilo
  - Kona
- Generation distributed around ring

Major Vulnerabilities

- Vegetation impacting power lines and access
- Fuel disruption
- Earthquakes
- Volcanic activity
- Spares, supplies and road access

Characteristics and Vulnerabilities of Existing Electricity Infrastructure - Maui

MAP REMOVED FOR CONFIDENTIALITY

Characteristics

- Load center at Kahului
- Resort and residential load along west coast
- Generation at Maalaea

Major Vulnerabilities

- Load center at Kahului
- One major generating plant
- Wildfire hazards
- Coastal flooding
- Spares, supplies and road access

Characteristics and Vulnerabilities of Existing Electricity Infrastructure – Moloka‘i

MAP REMOVED FOR CONFIDENTIALITY

Characteristics

- Directly connected to radial distribution feeds to customers
- Limited refueling capability during emergency

Major Vulnerabilities

- One generating plant
- Wildfire hazards
- Coastal flooding
- Spares, supplies and road access

Characteristics and Vulnerabilities of Existing Electricity Infrastructure – Lanaʻi

MAP REMOVED FOR CONFIDENTIALITY

Characteristics

- Directly connected to radial distribution feeds to customers
- Limited refueling capability during emergency

Major Vulnerabilities

- One generating plant
- Wildfire hazards
- Coastal flooding
- Spares, supplies and road access

Potential Options for Long-Term Plan

Some *Worst Case Scenarios May Have Weeks to Months for Full Restoration*

Generation

- Fuel supply
- Harbor and port facilities
- Decentralized resources
- Microgrids

Transmission

- Spare material and supplies
- Access to difficult sites
- Availability of helicopter support
- Resources – personnel, equipment, tools

Distribution

- Spare material and supplies
- Access (road clearing)
- Resources – personnel, equipment and supplies

Potential Grid Mitigation Strategies

Grid planning

- Transmission reinforcements, alternative paths
- Mix and location of generation
- Distributed energy resources
- Microgrids for key loads (connected to grid normally – available for self-supply in emergency)

System hardening

- Design standards
- Increased wind withstand ratings
- Elevate flood prone substations
- Upgrade structures; construction methods and materials
- Underground cabling
- Maintenance schedules and resources/spares

Emergency preparations

- Fuel assurance and increased storage
- Alternative port and delivery options for emergencies
- Increased amounts of critical supplies

Discussion Questions
Grid Resilience Options

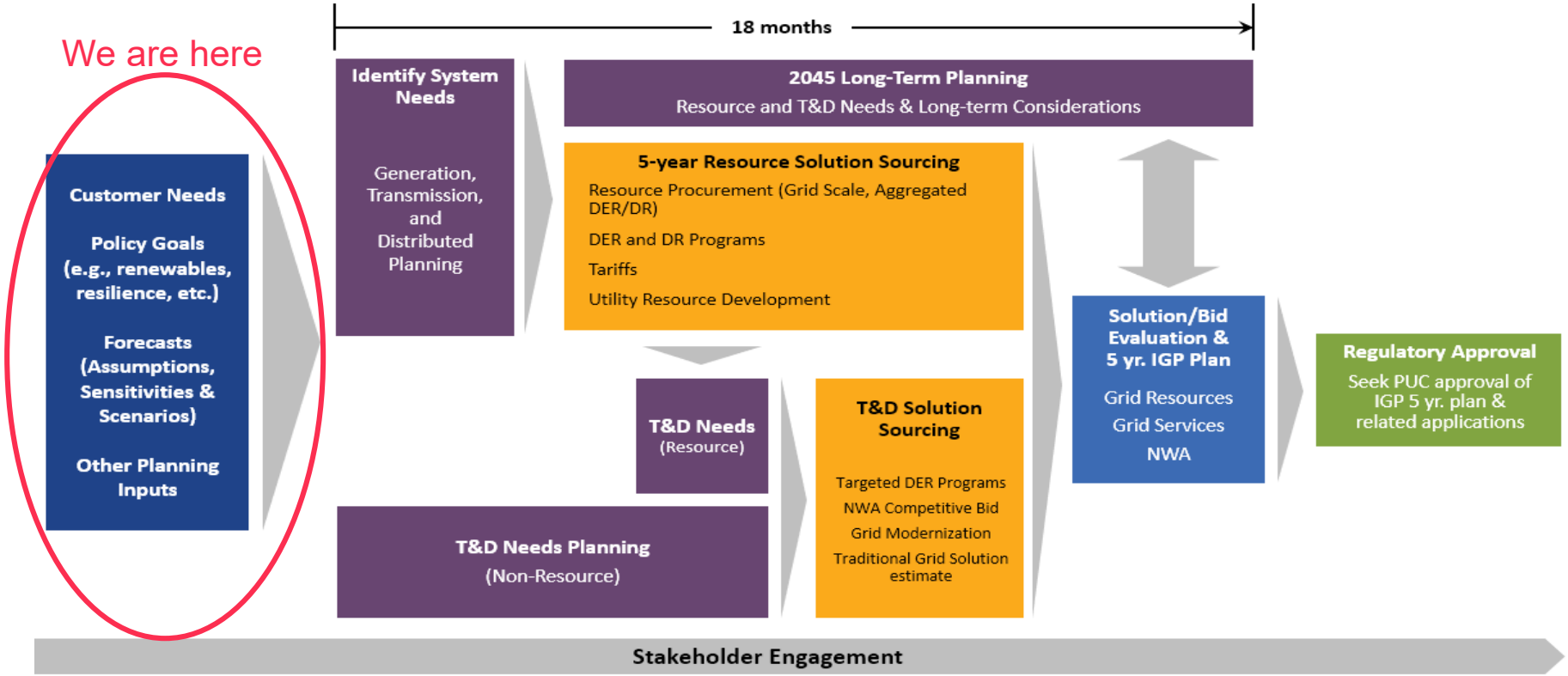
1. Do the grid resilience options described seem reasonable?

2. What additional options should be considered?

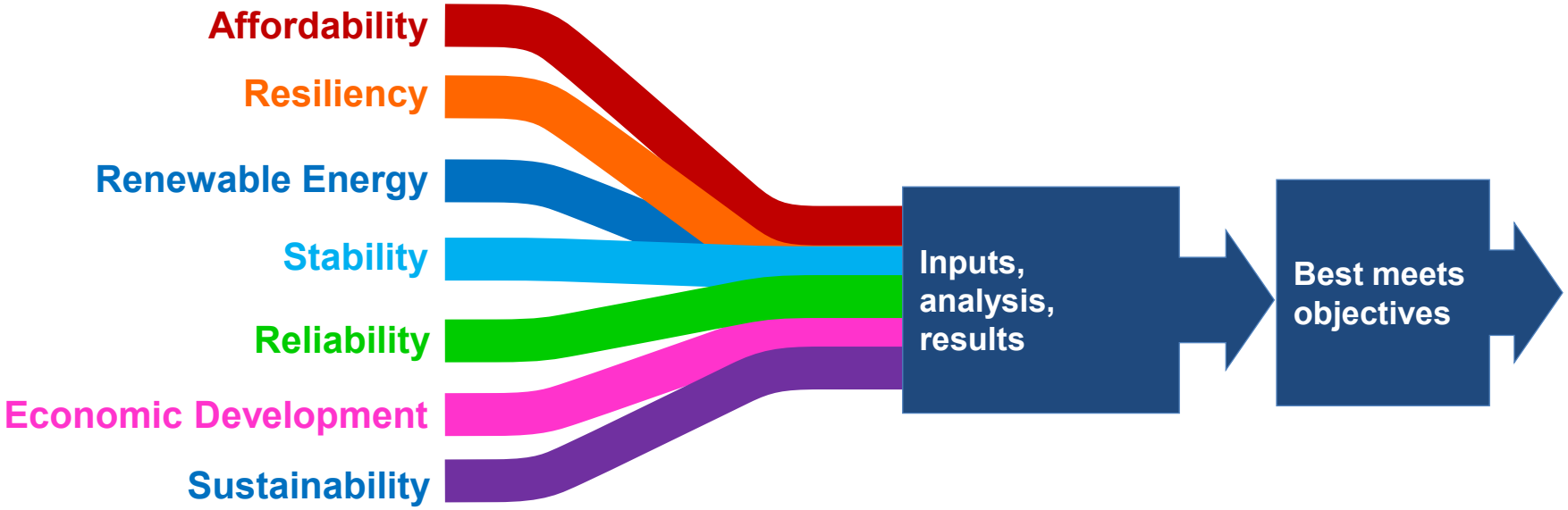
LUNCH BREAK AND JUPITER DEMO

RESILIENCE INPUTS TO INTEGRATED PLANNING PROCESS

Overview of HECO's Integrated Planning Process



Objectives - What Do Customers Want?



Overview of HECO's Integrated Planning Process

We are here

18 months

Other Inputs

Policy Goals
(Renewable, Resilience, etc.)

- Meeting renewable and carbon goals
- Tier 1 backup power available to maintain until restoration occurs under all scenarios
- Tier 2 power returned within days until restoration occurs under all scenarios

Forecasts
(Assumptions and forecasts)

- Future weather patterns (impacting surge etc.)
- Impacts of hurricanes, earthquakes, tsunamis, fires etc. on levels of flooding, wind damage
- Recovery times for locations on each island

Other Planning Inputs

- Days supply of power for each Tier 1 and 2 customer
- Days supply of fuel and water for each Tier 1 and 2 customer
- Vulnerability assessment, including downtimes for all Tiers of customers for each scenario

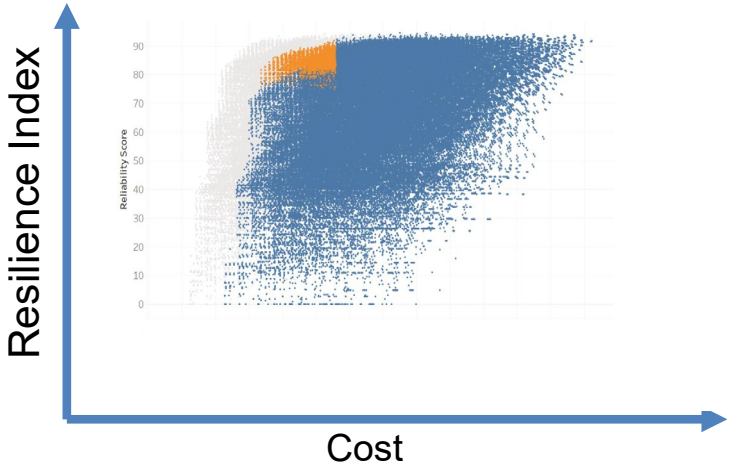
ory Approval

C approval of
yr. plan &
applications

Stakeholder Engagement

Resilience Measures and Composite Index

Resilience index measures how well a resilient grid performs under proposed severe threat scenarios. It is used to make comparisons among various strategies and options. The index is not a utility target or requirement – simply a measuring device to compare how well different solutions perform under severe circumstances.

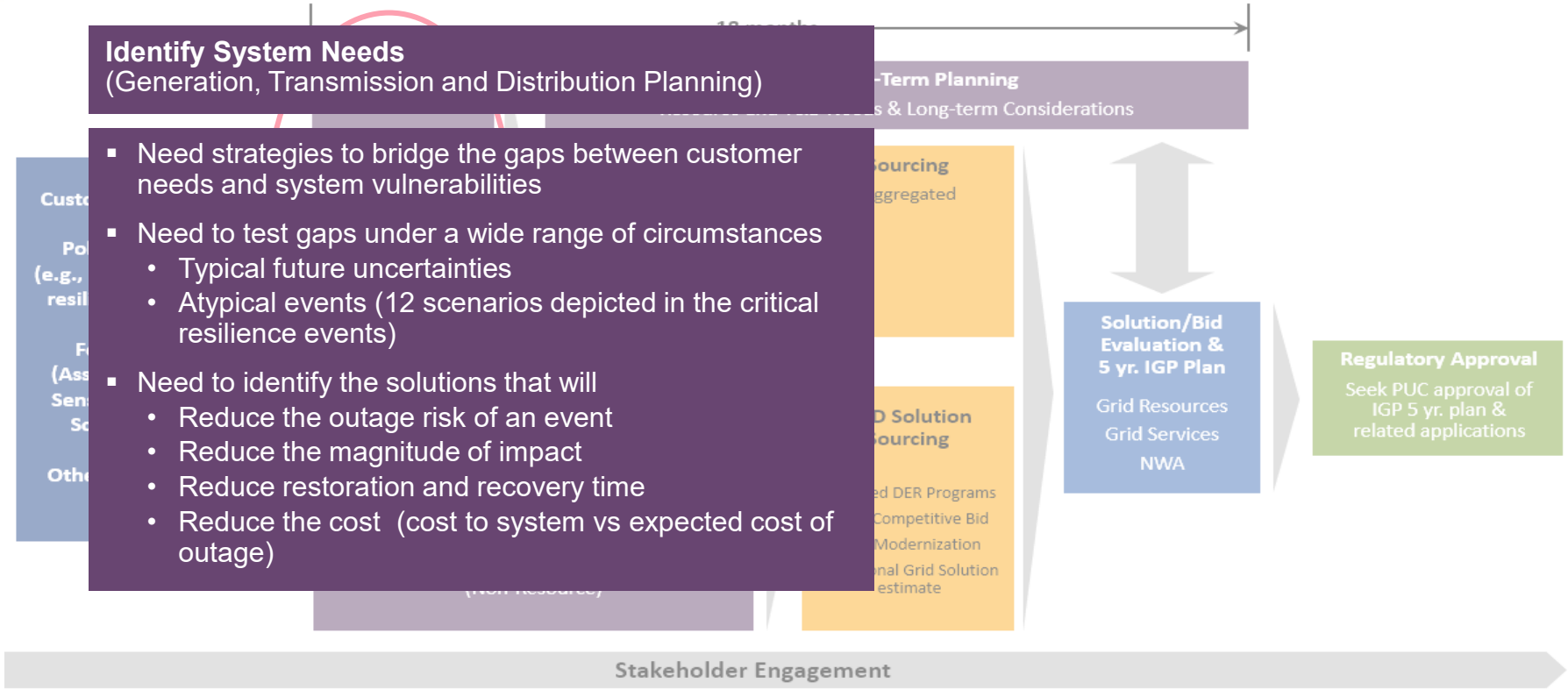


- Resilience Index (Sample Index Weighting Shown)
  - Percent of Tier 1 customer sites that lose offsite power day or less (25%)
  - Percent of Tier 2 customer sites that lose offsite power 3 days or less (15%)
  - Percent of Tier 3 customers that lose offsite power 14 days or less (10%)
  - Percent of Tier 1 customer sites restored within 3 days days (25%)
  - Percent of Tier 2 customer sites restored within 7 days days (15%)
  - Percent of tier 3 customers restored within 28 days (10%)
- Cost

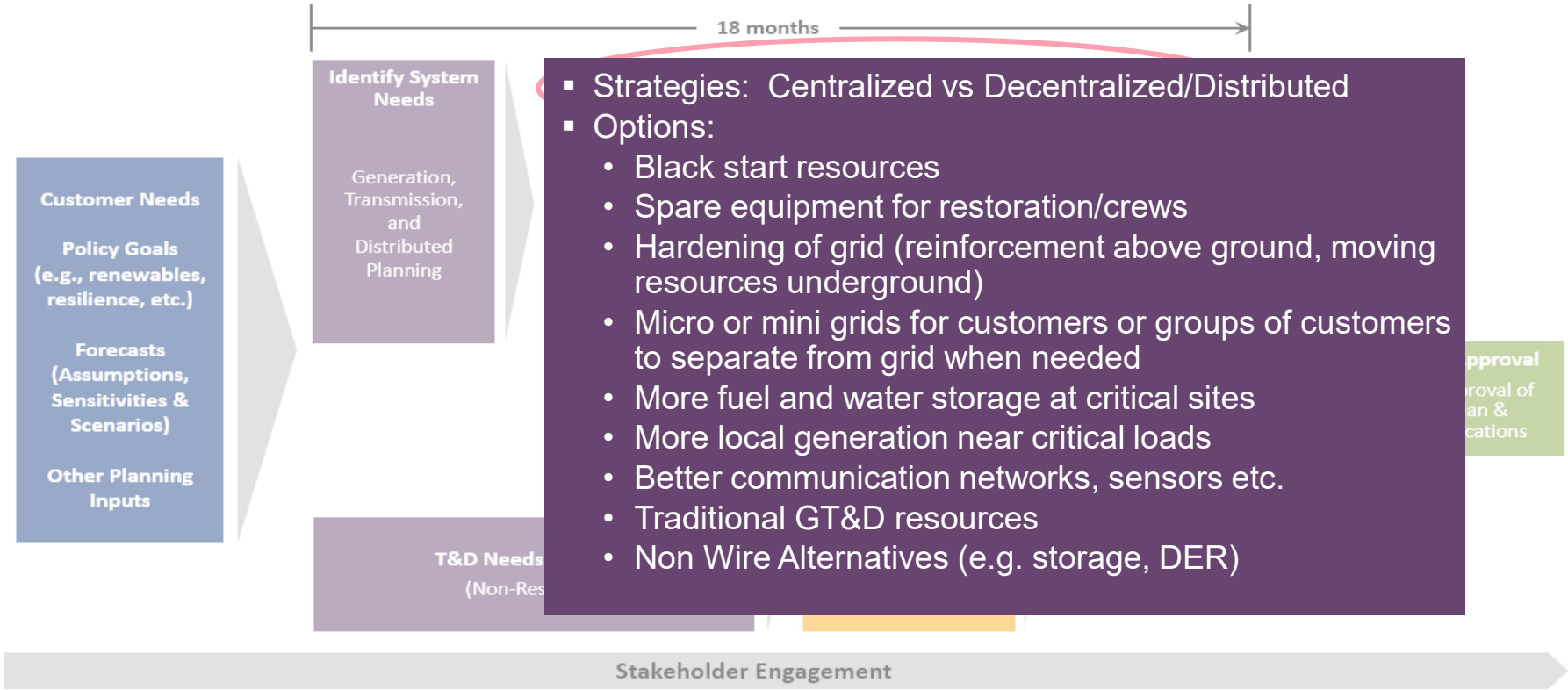
Overview of HECO's Integrated Planning Process

Identify System Needs
(Generation, Transmission and Distribution Planning)

- Need strategies to bridge the gaps between customer needs and system vulnerabilities
- Need to test gaps under a wide range of circumstances
  - Typical future uncertainties
  - Atypical events (12 scenarios depicted in the critical resilience events)
- Need to identify the solutions that will
  - Reduce the outage risk of an event
  - Reduce the magnitude of impact
  - Reduce restoration and recovery time
  - Reduce the cost (cost to system vs expected cost of outage)



Overview of HECO's Integrated Planning Process



- Strategies: Centralized vs Decentralized/Distributed
- Options:
  - Black start resources
  - Spare equipment for restoration/crews
  - Hardening of grid (reinforcement above ground, moving resources underground)
  - Micro or mini grids for customers or groups of customers to separate from grid when needed
  - More fuel and water storage at critical sites
  - More local generation near critical loads
  - Better communication networks, sensors etc.
  - Traditional GT&D resources
  - Non Wire Alternatives (e.g. storage, DER)

Potential Options for Long-Term Plan

Generation

- Fuel supply
- Harbor and port facilities
- Decentralized resources
- Microgrids

Transmission

- ROW easements and vegetation management
- Spare material and supplies
- Access to difficult sites
- Availability of helicopter support
- Resources – personnel, equipment, tools

Distribution

- Spare material and supplies
- Access (road clearing)
- Resources – personnel, equipment and supplies

Potential Grid Mitigation Strategies

Grid planning

- Transmission reinforcements, alternative paths
- Mix and location of generation
- Distributed energy resources
- Microgrids for key loads (connected to grid normally – available for self-supply in emergency)

System hardening

- Design standards
- Increased wind withstand ratings
- Elevate flood prone substations
- Upgrade structures; construction methods and materials
- Underground cabling
- Maintenance schedules and resources/spares

Emergency preparations

- Fuel assurance and increased storage
- Alternative port and delivery options for emergencies
- Increased amounts of critical supplies
- Restorations plans, training and drills

Sample Score Card Summary of Portfolio Options

Criteria		Affordability			Resilience	Sustainability	
Portfolio		2020-2030 Cost NPV ($Mil)	2020-2040 Levelized Cost (2019 $/MWh)	Cost Rating Score	Resilience Composite	CO_2 Changes from (%)	Renewable Generation As % of Load (%)
Status Quo							
Portfolio 1							
Portfolio 2							
Portfolio 3							
Portfolio 4							
Portfolio 5							
Portfolio 6							
Portfolio 7							
Portfolio 8							
Portfolio 9							

Discussion Questions
Inputs to Integrated Planning Process

1. Are the resilience objectives appropriate for input to the Integrated Grid Planning Process?

2. Are the grid planning solutions suggested reasonable and preferred? What other solutions would you offer?

3. Are there any suggested planning solutions that customers feel are not acceptable?

4. Are the grid resilience criteria and scorecard acceptable? What improvements would you suggest?

NEXT STEPS AND CLOSING REMARKS

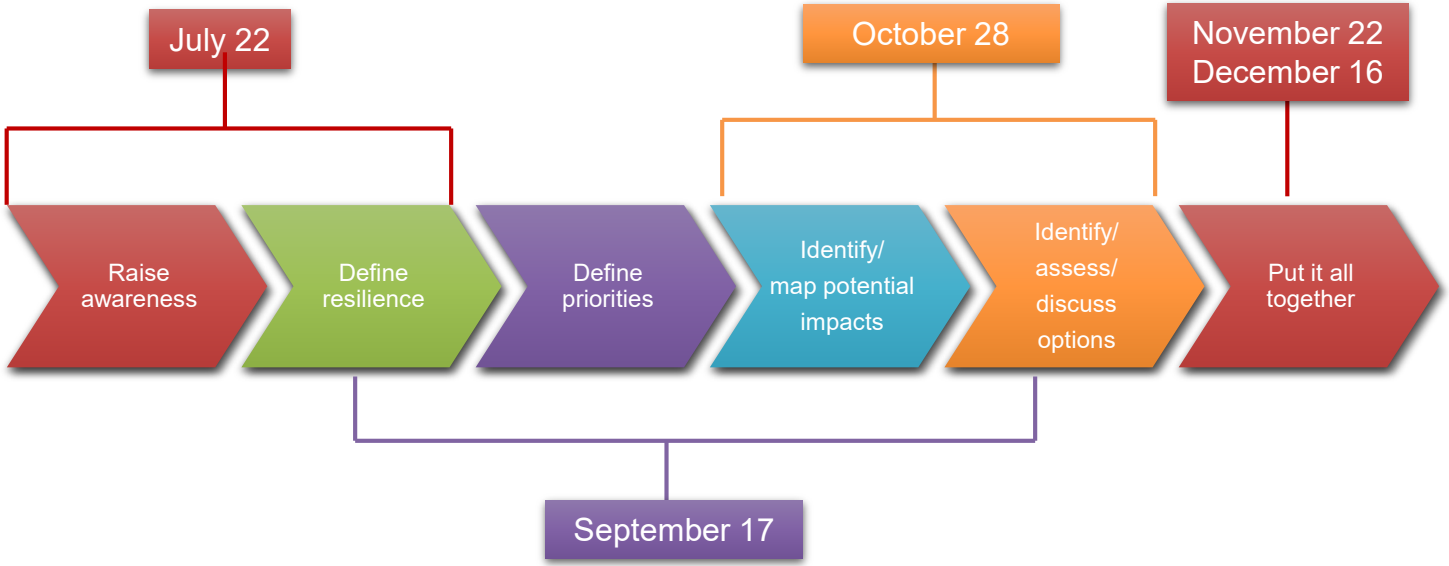
Next Steps

- Meeting presentation and summary will be made available on the IGP website

  https://www.hawaiianelectric.com/clean-energy-hawaii/integrated-grid-planning/stakeholder-engagement/working-groups/resilience-documents

- Plans for posting and review of draft report

IGP RWG Process Overview (Update)




Mahalo!