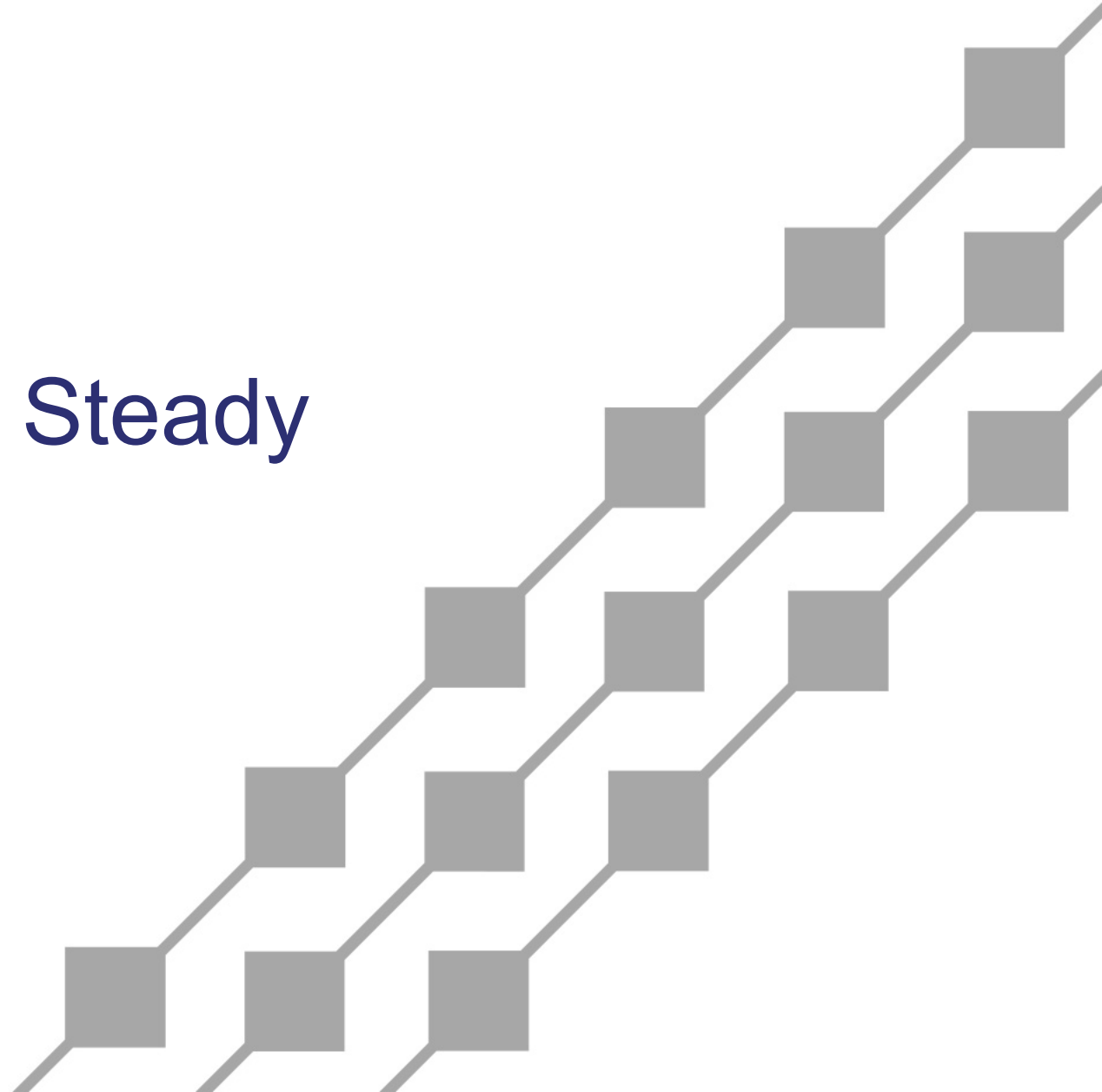


**Hawaiian  
Electric**

# Maui IGP-SSS: 2028-2050 Preliminary Steady State Results

January 13, 2023



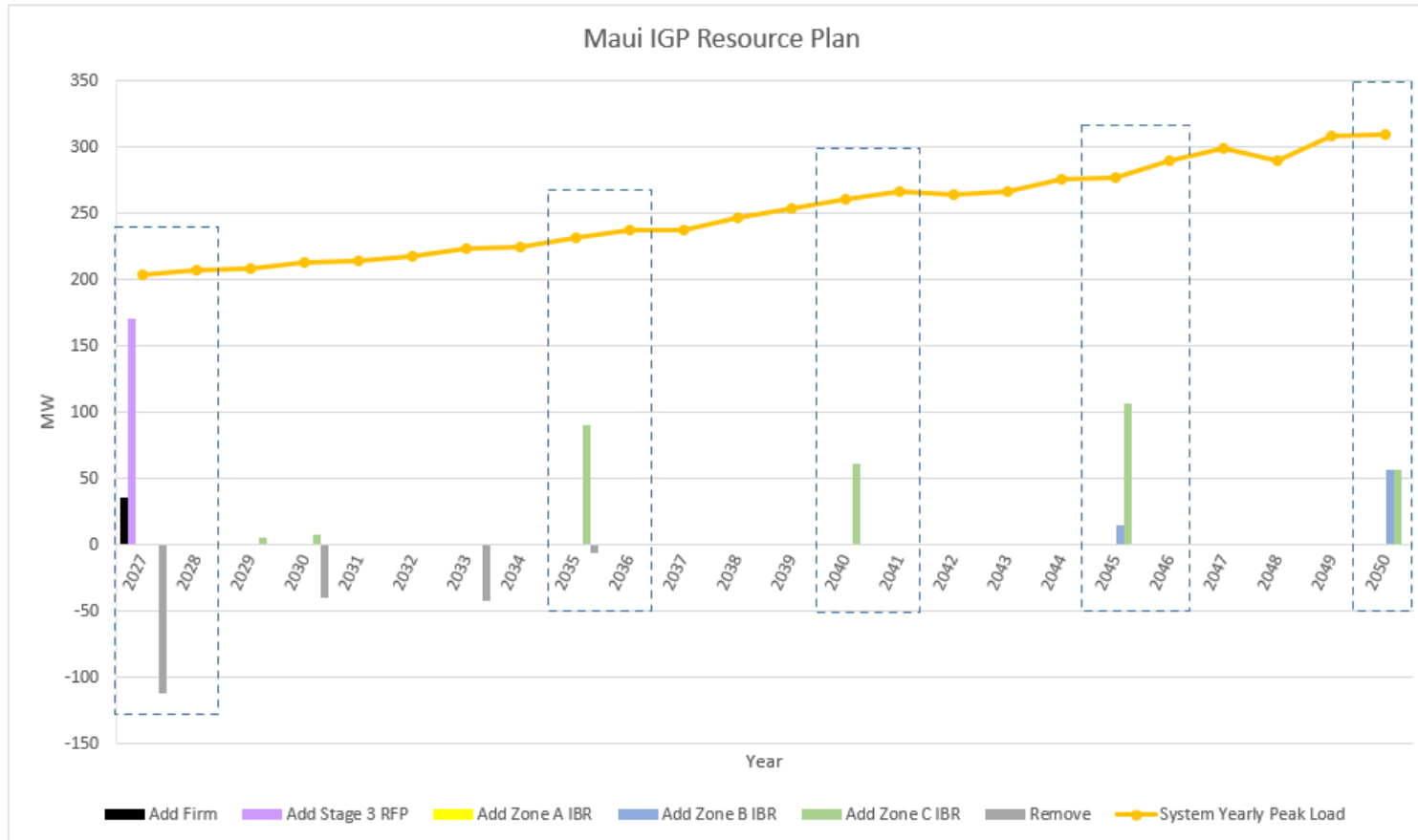
# Study Summary

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- ◆ Study objective – identify transmission steady state grid needs to host the forecasted load and resource interconnections, from near term to 2050.
- ◆ Study approach – Perform power flow analyses for selected years with peak load, without DER contribution.



# Studied Years



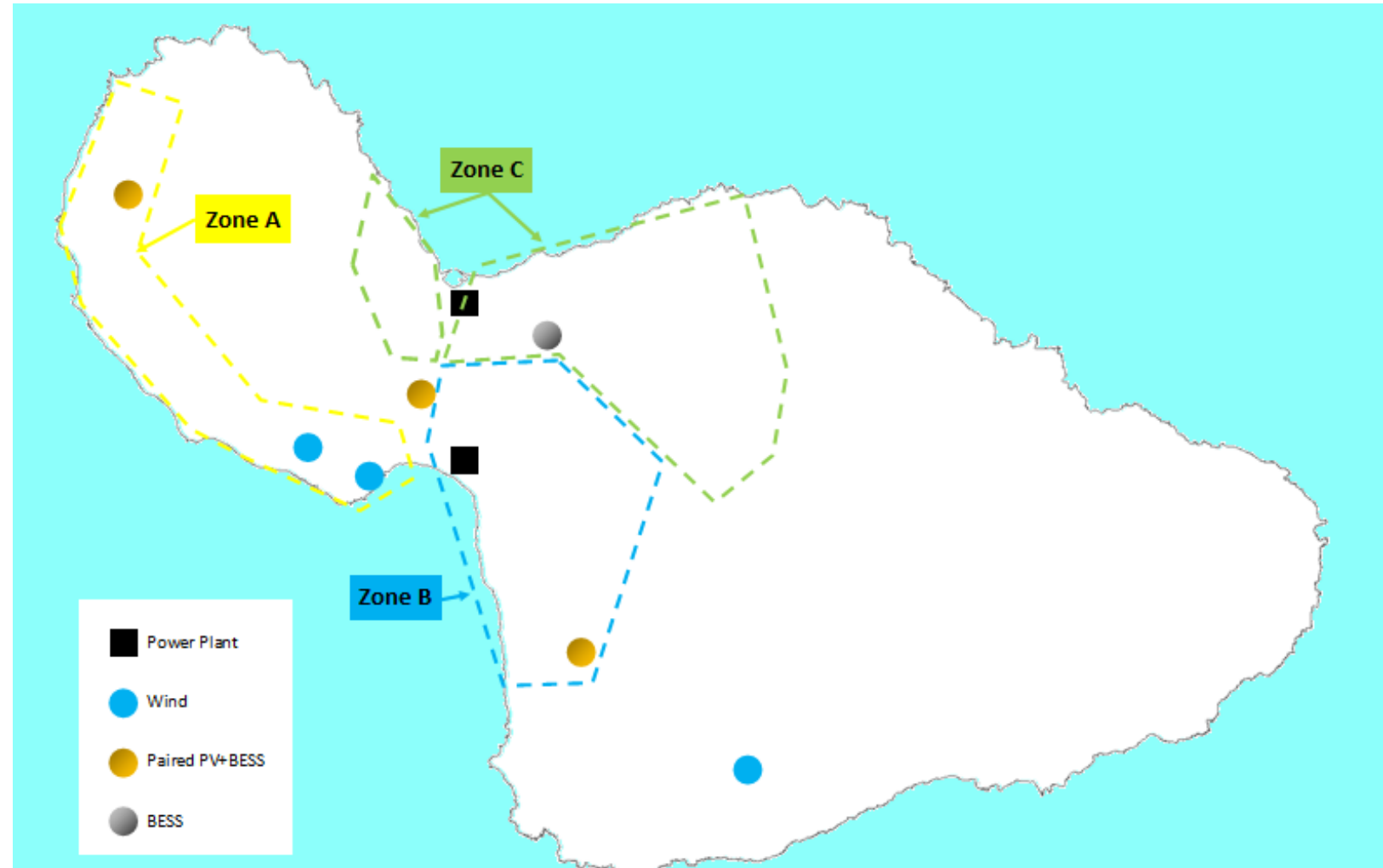
- ◆ Select studied years with significant grid scale generation increase.
- ◆ For future IPP placement, take locations with capacity first.



# Dispatch Strategy

Dispatch
Zone A
Zone B*
Zone C*
Zone A+C
Zone B+C
Zone A+B
All Zones

\*Variation dispatches in earlier years, due to less resources in each zone and less system mitigation

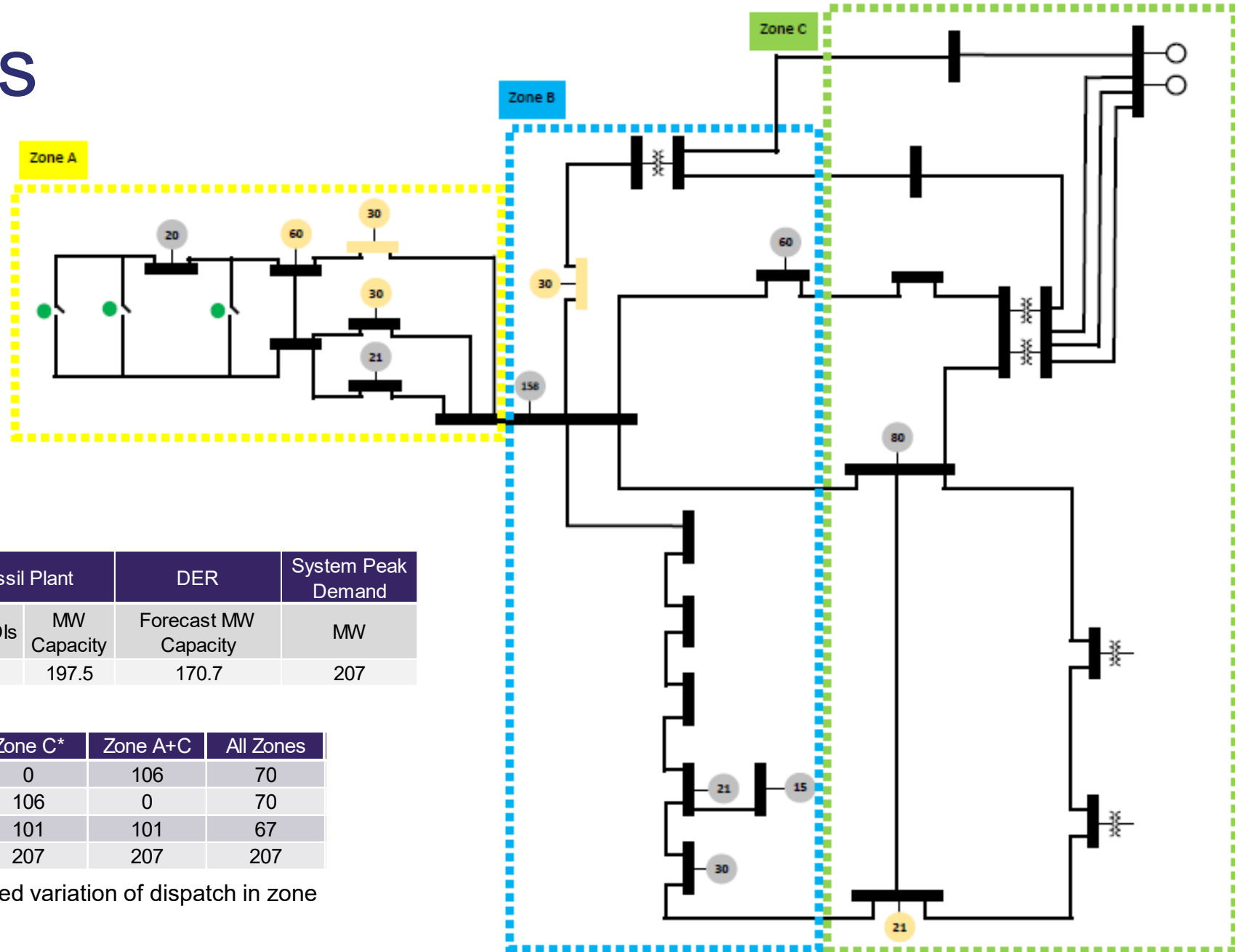


# 2028 Analyses

## Dispatch

**LEGEND**

- Existing Generation / Stage 1 & 2 Projects / Company Project
- 2028 Additions
- Sync Condenser
- 69/23kV Tie Transformer
- Normally Open Point



### 2028 Resource Interconnections

Base Load	PV/BESS IBR		Wind		Fossil Plant		DER	System Peak Demand
	# of POIs	MW Capacity	# of POIs	MW Capacity	# of POIs	MW Capacity	Forecast MW Capacity	
2028	10	336	2	42	2	197.5	170.7	207

### 2028 Dispatch Cases

Max Rating	Zone A	Zone B*	Zone C*	Zone A+C	All Zones
Zone A	161	0	0	106	70
Zone B	46	207	106	0	70
Zone C	0	0	101	101	67
Total Load	207	207	207	207	207

\*Studied variation of dispatch in zone



# 2028 Analyses

## Results Summary

---

- ◆ No normal configuration equipment overloading or voltage violation.
- ◆ Equipment violation identified in N-1
- ◆ West Maui N-1 SPOF violation
  - Potential Max Generation Loss = 110 MW

Dispatch	# of Contingencies w/ Overloading	Overloading Equipment	Overloading Range
Zone A	1	69 kV line	120-130%
Zone B_1	1	69/23 kV Tie Tsf	95-100%
Zone B_2	0	None	None
Zone C_1	1	69/23 kV Tie Tsf	95-100%
Zone C_2	3	69 kV line; 69/23kV Tie Tsf	95-102%
Zone A+C	0	None	None
All Zones	0	None	None



# 2028 Analyses

## Results Summary

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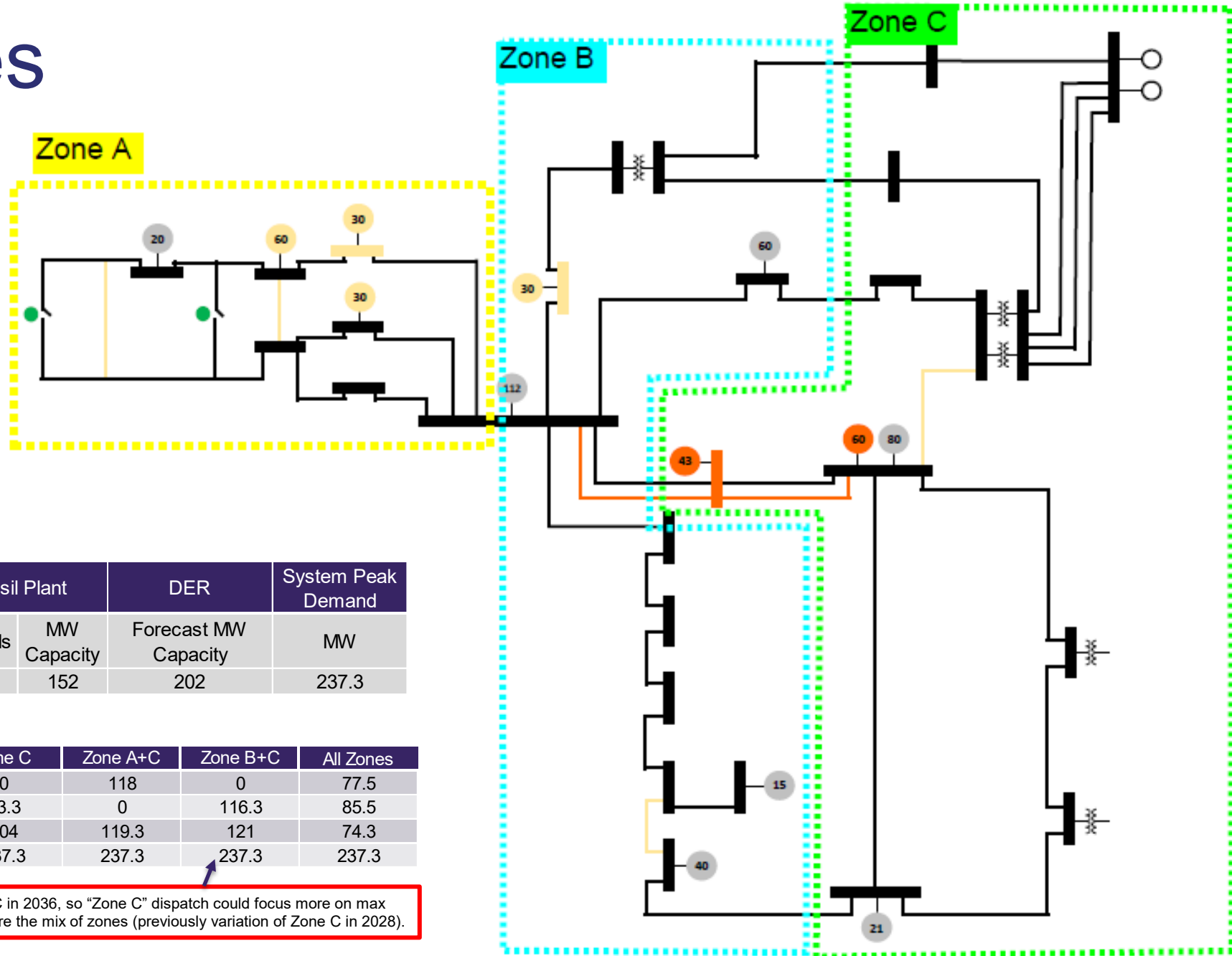
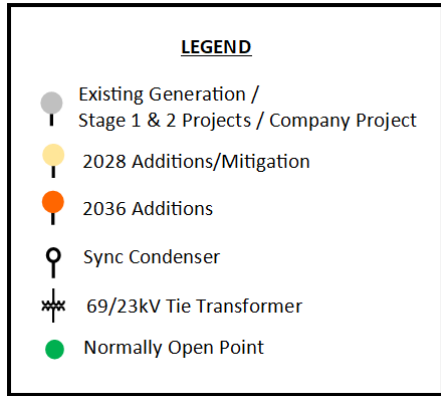
### ◆ Mitigation solution

- West Maui N-1 SPOF mitigation – close loop in West Maui radial 69 kV circuits.
  - Without upgrades: Install 17 MW vs. 90 MW
- 69 kV line overloading – reconductoring overloaded line from 336 AAC to 556 AAC.
  - Alternative: Redispatch system
    - Zone A Violation: Redispatch 24MW
      - Matters which units are redispatched in Zone A
    - Zone C Violation: Redispatch 18 MW
      - When redispatching from Zone C to Zone B, it matters which units are used in Zone B



# 2036 Analyses

## Dispatch



### 2036 Resource Interconnections

Base Load	PV/BESS IBR		Wind		Fossil Plant		DER	System Peak Demand
	# of POIs	MW Capacity	# of POIs	MW Capacity	# of POIs	MW Capacity	Forecast MW Capacity	
Year								MW
2036	10	373	2	66	2	152	202	237.3

### 2036 Dispatch Cases

Max Rating	Zone A	Zone B*	Zone C	Zone A+C	Zone B+C	All Zones
Zone A	140	140	0	118	0	77.5
Zone B	257	97.3	237.3	33.3	0	85.5
Zone C	204	0	0	119.3	121	74.3
Total Load	237.3	237.3	237.3	237.3	237.3	237.3
% Growth Increase from 2028	15%					

More resources were added to Zone C in 2036, so "Zone C" dispatch could focus more on max export. Zone B+C was added to capture the mix of zones (previously variation of Zone C in 2028).

\*Studied variation of dispatch in zone



# 2036 Analyses

## Results Summary

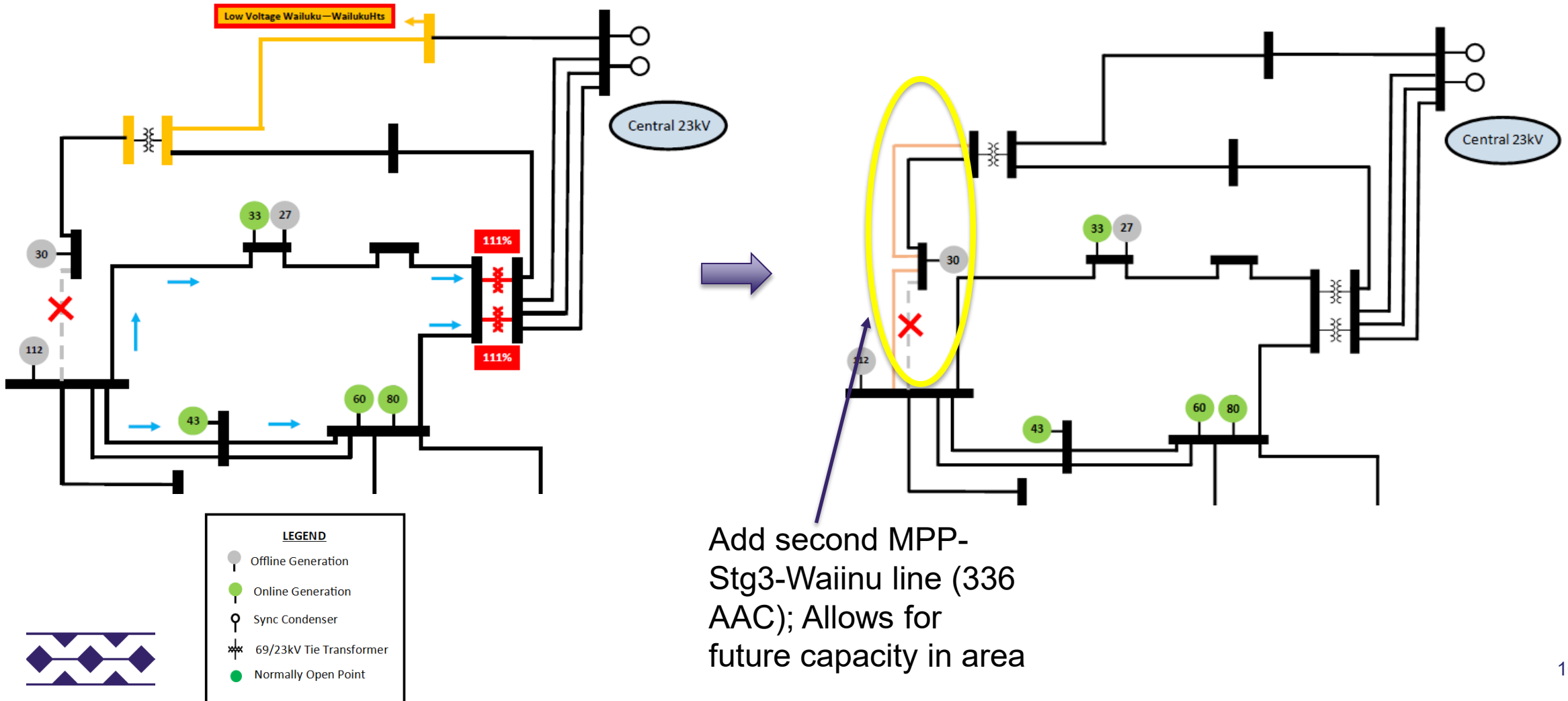
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- ◆ No normal configuration equipment overloading or voltage violation
- ◆ Equipment violation identified in N-1
- ◆ Undervoltage violation

Dispatch	# of Contingencies w/ Overloading	Overloading Equipment	Overloading Range
Zone A	1	69/23 kV Tie Tsf	101-111%
Zone B_1	1	69/23 kV Tie Tsf	101-111%
Zone C	2	69/23 kV Tie Tsf	101-110%
Zone A+C	2	69/23 kV Tie Tsf	101-110%
Zone B+C	2	69/23 kV Tie Tsf	101-110%
All Zones	1	69/23 kV Tie Tsf	101-110%



# 2036 Mitigation: 69/23kV Tsf Overloading & Low Voltage

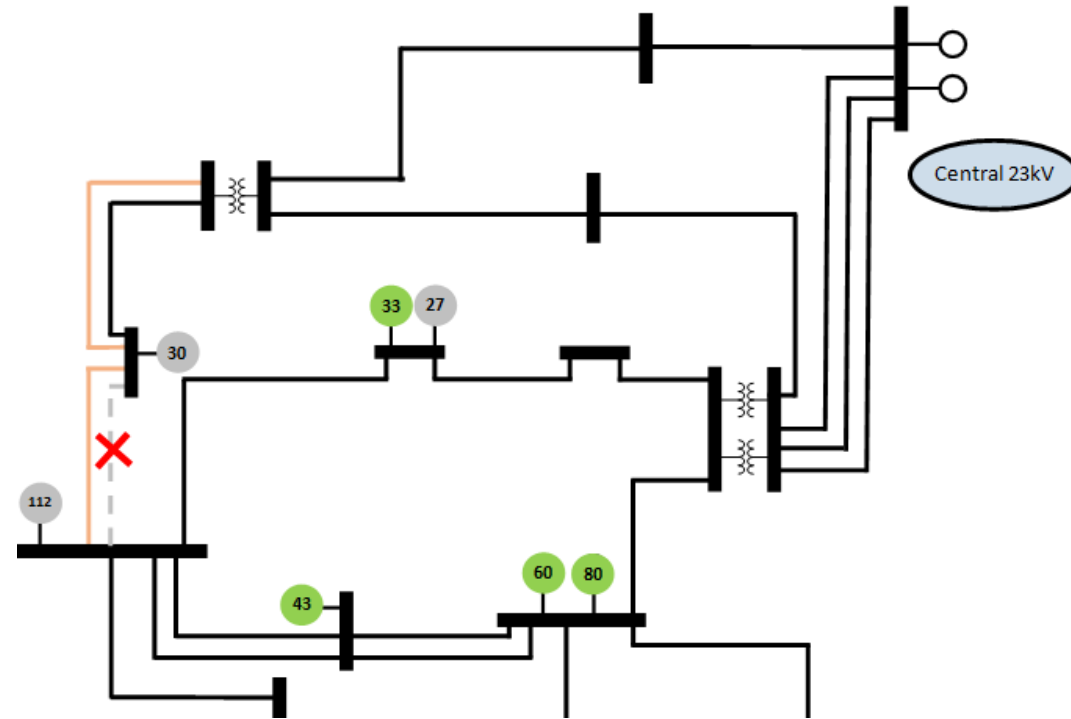


# 2036 Analyses

## Results Summary

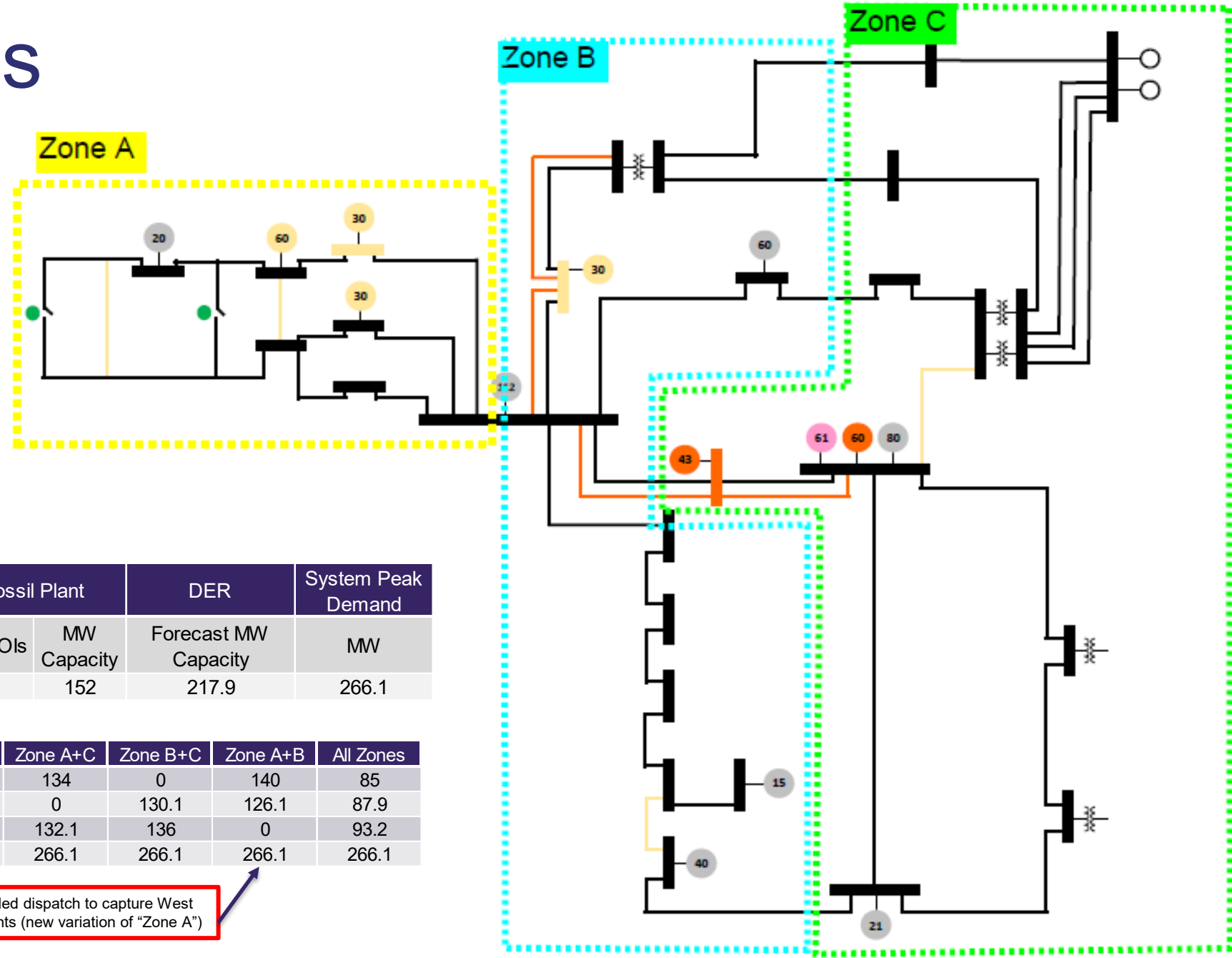
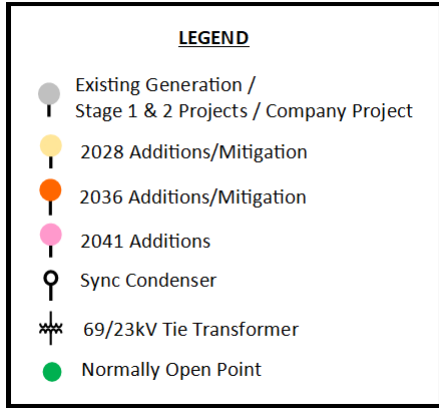
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- ◆ Mitigation solution
  - Add second 336 AAC circuit from MPP-STG3.1 POI-Waiinu (resolve both overloading and undervoltage issues)
  - Alternatives
    - Add generation in 23 kV substation, at least 8 MW generation, MWH requirement TBD; Location – Waiinu or Kanaha
    - Upgrading Waiinu-Kahului and Kahului-Kanaha from 23kV to 69kV
    - Upgrading both Kanaha Tie Transformers



# 2041 Analyses

## Dispatch



### 2041 Resource Interconnections

Base Load	PV/BESS IBR		Wind		Fossil Plant		DER	System Peak Demand
Year	# of POIs	MW Capacity	# of POIs	MW Capacity	# of POIs	MW Capacity	Forecast MW Capacity	MW
2041	11	416	2	84	2	152	217.9	266.1

### 2041 Dispatch Cases

Max Rating	Zone A	Zone B	Zone C	Zone A+C	Zone B+C	Zone A+B	All Zones
Zone A	140	0	0	134	0	140	85
Zone B	126.1	257	1.1	0	130.1	126.1	87.9
Zone C	0	9.1	265	132.1	136	0	93.2
Total Load	266.1	266.1	266.1	266.1	266.1	266.1	266.1
% Growth Increase from 2028	29%						

With increased load, added dispatch to capture West and max from South plants (new variation of "Zone A")

# 2041 Analyses

## Results Summary

---

- ◆ No normal configuration equipment overloading.
- ◆ UV violation identified in normal configuration case, due to load increase.
- ◆ Equipment violation identified in N-1

Dispatch	# of Contingencies w/ Overloading	Overloading Equipment	Overloading Range
Zone A	2	69 kV Line	95-100%
Zone B	0	None	None
Zone C	4	69 kV Line	95-115%
Zone A+C	2	69 kV Line	95-100%
Zone B+C	0	None	None
Zone A+B	0	None	None
All Zones	0	None	None



# 2041 Analyses

## Results Summary

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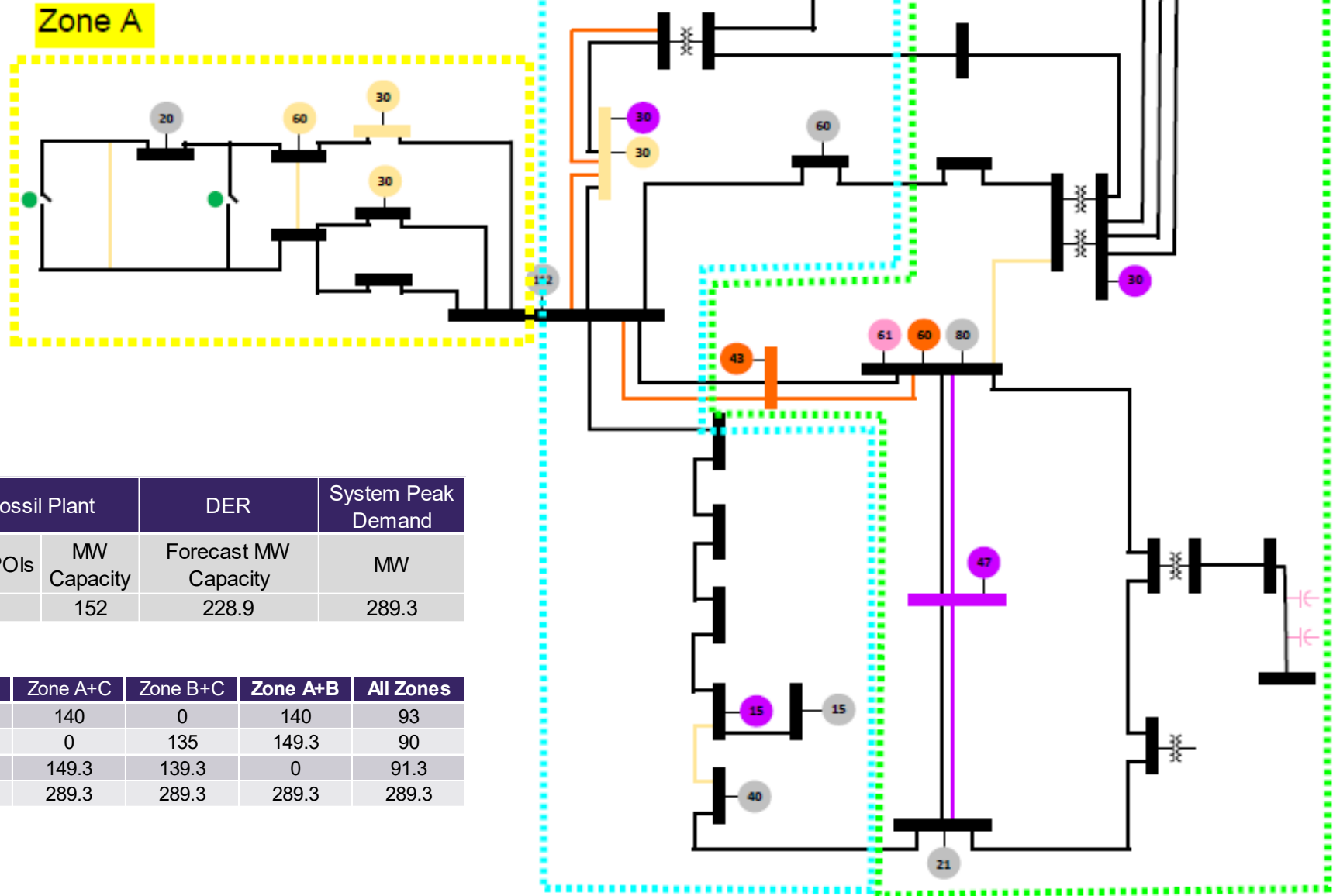
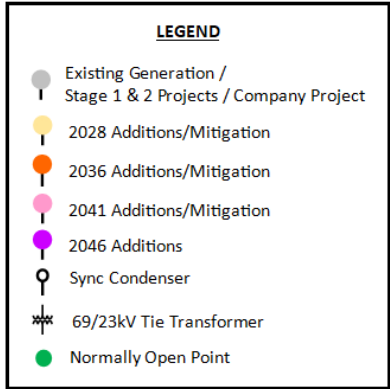
### ◆ Mitigation solutions

- 69 kV line overloading – redispatch system by avoiding excessive generation from Waena or MPP-Waena
  - Alternative – Increase capacity on overloaded lines
- Undervoltage issue - Add (2) 3.6MVAR cap banks to Pukalani-Hana line.



# 2046 Analyses

## Dispatch



### 2046 Resource Interconnections

Base Load	PV/BESS IBR		Wind		Fossil Plant		DER	System Peak Demand
Year	# of POIs	MW Capacity	# of POIs	MW Capacity	# of POIs	MW Capacity	Forecast MW Capacity	MW
2046	14	497	3	125	2	152	228.9	289.3

### 2046 Dispatch Cases

	Max Rating	Zone A	Zone B	Zone C	Zone A+C	Zone B+C	Zone A+B	All Zones
Zone A	140	140	0	0	140	0	140	93
Zone B	272	149.3	272	0	0	135	149.3	90
Zone C	372	0	17.3	289.3	149.3	139.3	0	91.3
Total Load	289.3	289.3	289.3	289.3	289.3	289.3	289.3	289.3
% Growth Increase from 2028	40%							

# 2046 Analyses

## Results Summary

---

- ◆ 69 kV line overloading observed in both normal configuration and N-1 contingency, caused by both load growth and generation congestion.
- ◆ No voltage violation identified.

Dispatch	# of Contingencies w/ Overloading	Overloading Equipment	Overloading Range
Zone A	6*	69 kV Line	95-105%
Zone B	1	69 kV Line	95-105%
Zone C	7	69 kV Line	95-105%
Zone A+C	5	69 kV Line	101-110%
Zone B+C	1	69kV Line	95-105%
Zone A+B	1	69 kV Line	95-105%
All Zones	1	69 kV Line	95-100%

\*Normal case shows violation





# 2046 Analyses

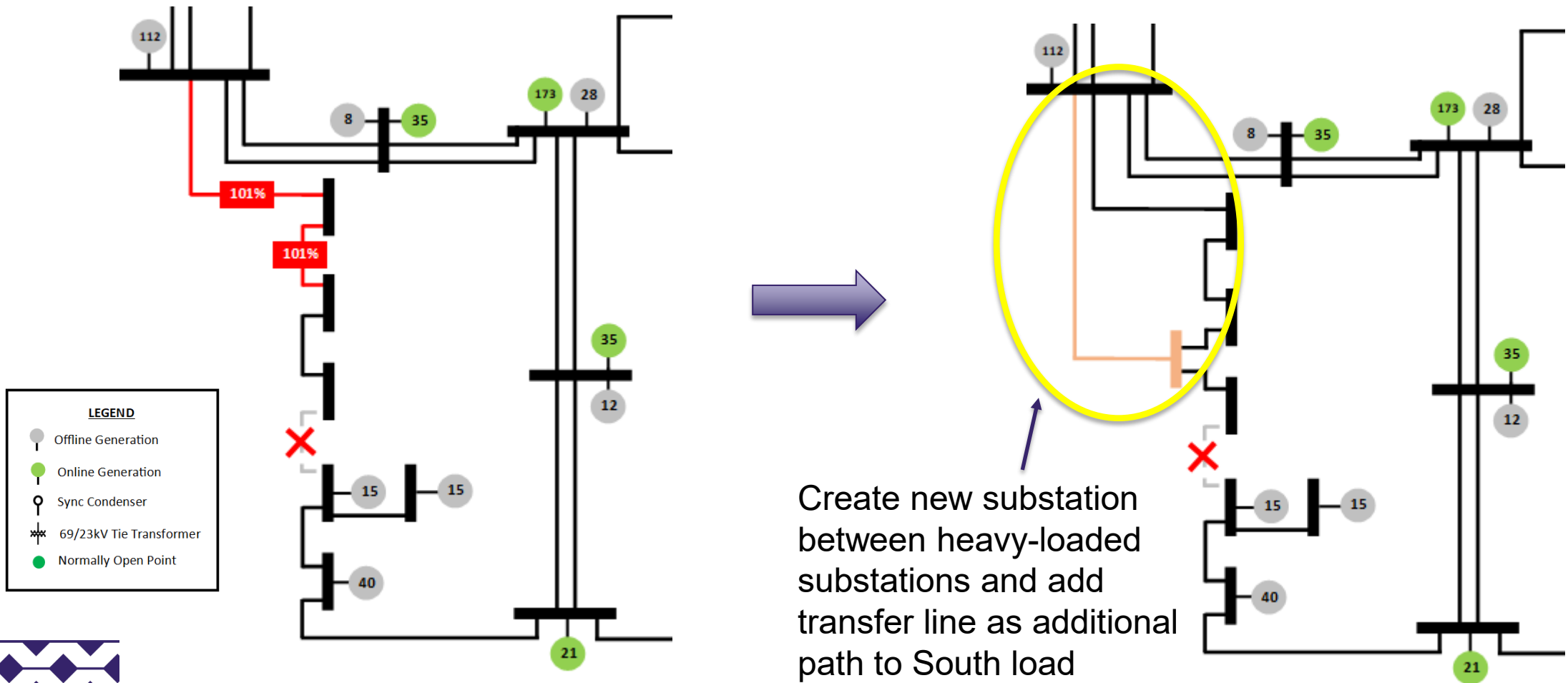
## Results Summary

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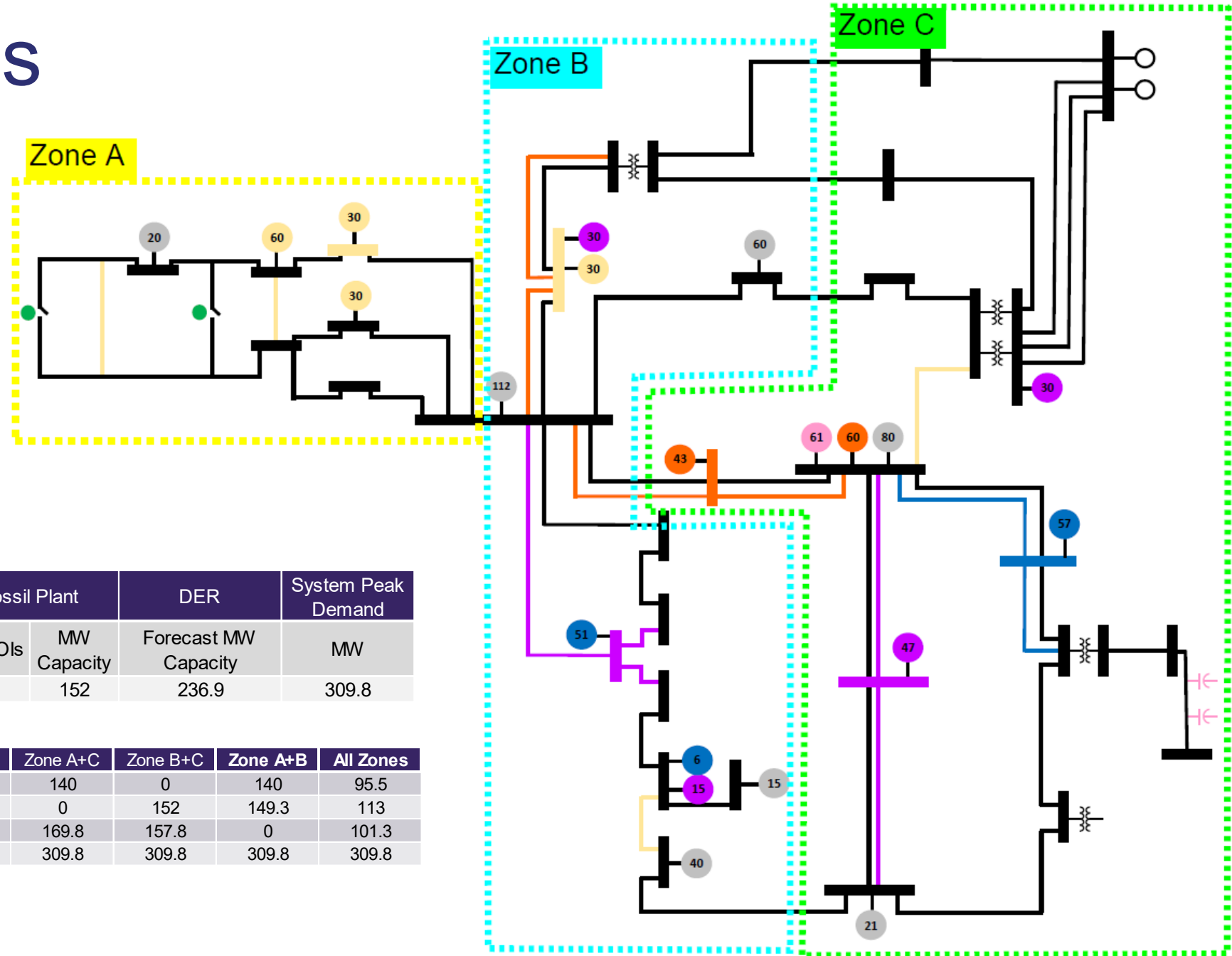
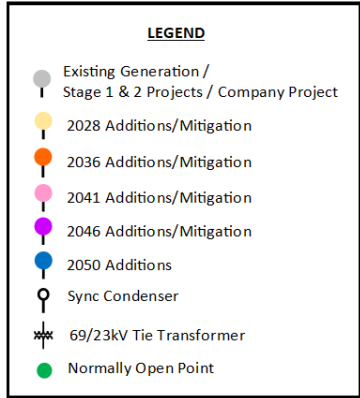
- ◆ Mitigation solutions
  - 69 kV line overloading
    - Adding a new line in south Maui to address overloading caused by load increase
      - Alternative – relying on DER on distribution side to reduce load
    - Avoid max dispatch from Zone A with certain plants in Zone B
      - Alternative – Increase capacity on overloaded lines
    - Redispatch system by avoiding excessive generation from Waena or MPP-Waena to address congestion issue
      - Alternative – Increase capacity on overloaded lines
  - Monitor 23kV load on Pukalani-Hana line, if load continues to grow



# 2046 Mitigation: 69kV Line Overloading



# 2050 Analyses Dispatch



## 2050 Resource Interconnections

Base Load	PV/BESS IBR		Wind		Fossil Plant		DER	System Peak Demand
	# of POIs	MW Capacity	# of POIs	MW Capacity	# of POIs	MW Capacity	Forecast MW Capacity	MW
2050	16	611	3	125	2	152	236.9	309.8

## 2050 Dispatch Cases

Max Rating	Zone A	Zone B	Zone C	Zone A+C	Zone B+C	Zone A+B	All Zones
Zone A	140	0	0	140	0	140	95.5
Zone B	169.8	309.8	0	0	152	149.3	113
Zone C	0	0	309.8	169.8	157.8	0	101.3
Total Load	309.8	309.8	309.8	309.8	309.8	309.8	309.8
% Growth Increase from 2028	50%						

# 2050 Analyses

## Results Summary

---

- ◆ No normal configuration equipment overloading.
- ◆ 69/23 kV tie transformer and 69 kV line overloading are observed during N-1 contingencies.

Dispatch	# of Contingencies w/ Overloading	Overloading Equipment	Overloading Range
Zone A	0	None	None
Zone B	3	69 kV Line, 69/23 kV Tie Tsf	95-105%
Zone C	5	69 kV Line	95-125%
Zone A+C	2	69/23 kV Tie Tsf	95-100%
Zone B+C	2	69/23 kV Tie Tsf	101-105%
Zone A+B	1	69 kV Line	101-105%
All Zones	0	None	None



# 2050 Analyses

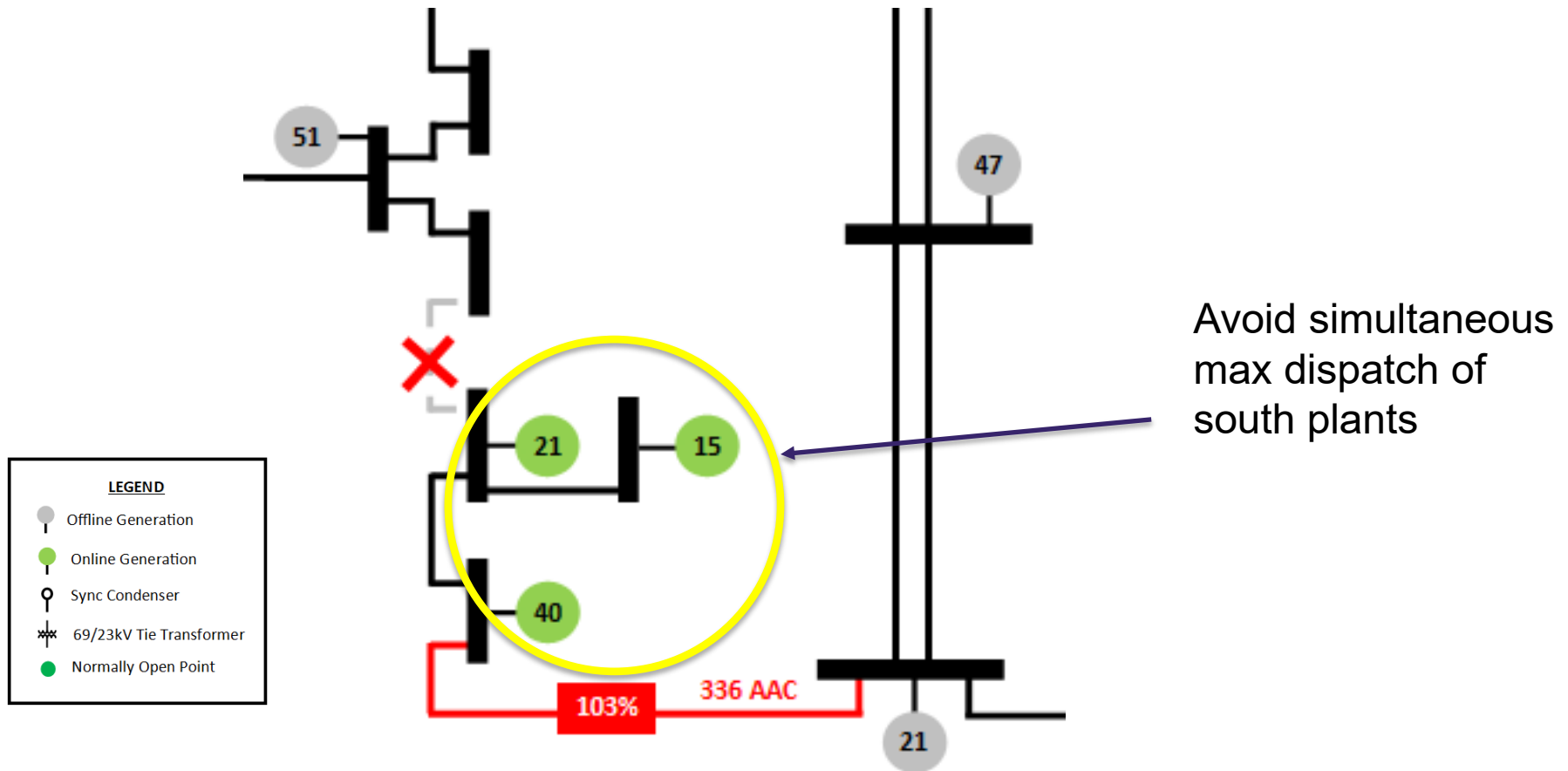
## Results Summary

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- ◆ Mitigation solutions
  - 69 kV line overloading
    - Redispatch system or avoid max simultaneous South dispatch
      - Alternative – Increase capacity on overloaded line
    - Redispatch system by avoiding excessive generation from Waena MPP-Waena to address congestion issue
      - Alternative – Increase capacity on overloaded lines
  - 69/23 kV tie transformer overloading
    - Redispatch system by using 23kV generation
      - Alternative - Reduce load on the 23kV system (i.e. Upgrade 23kV to 69kV to transfer load to 69kV system, rely on DER technology on distribution side to reduce area load, etc.)

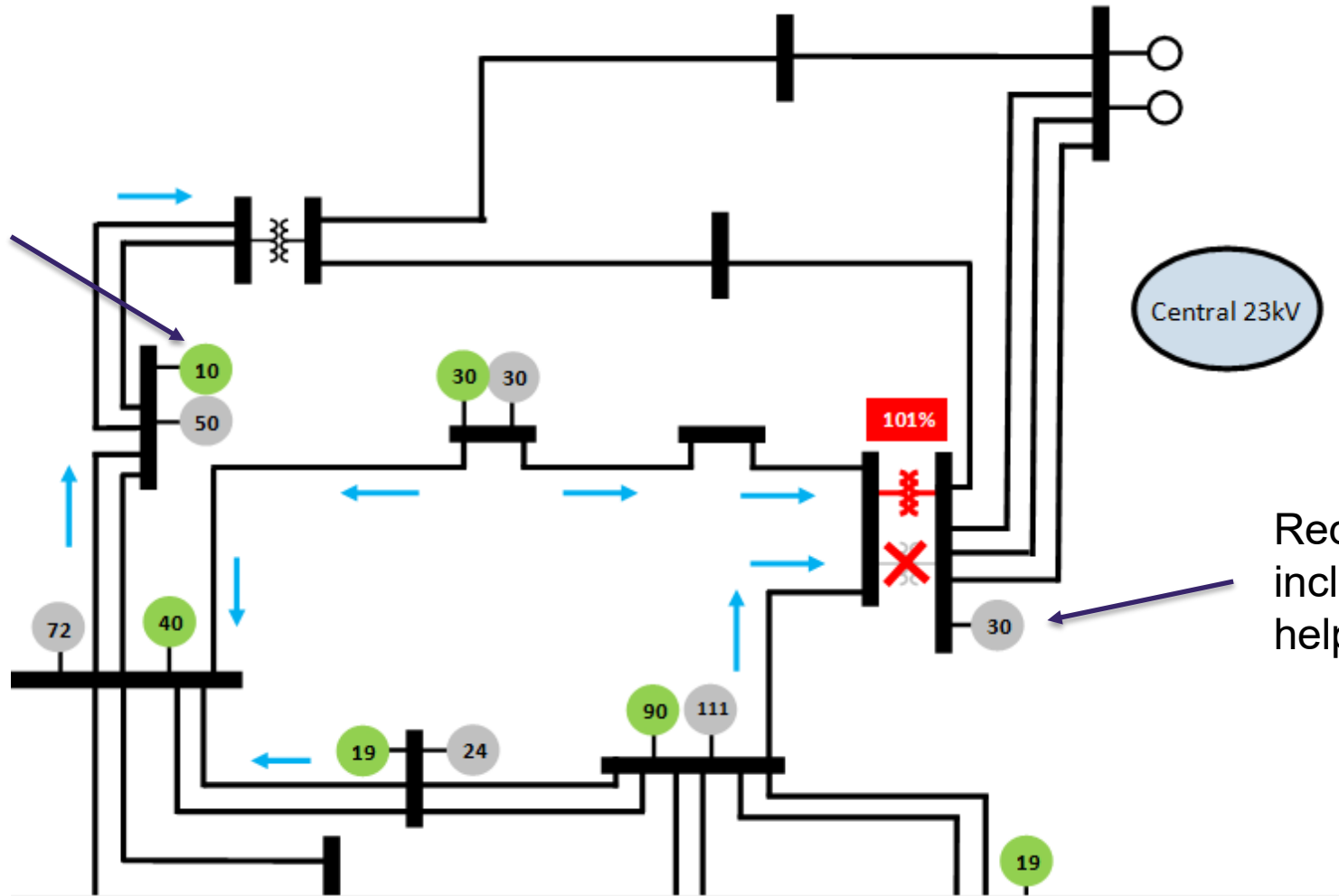
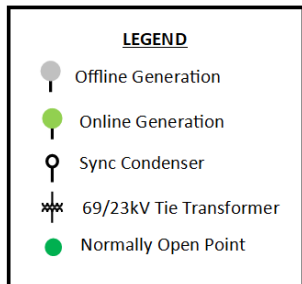


# 2050 Mitigation: 69kV Line Overloading



# 2050 Mitigation: 69/23kV Tie Tsf Overloading

Additionally, generation can also be increased in this area



Redispatch system to include 23kV generation to help lower 23kV load

# Conclusion: Base Case Study

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- ◆ Future resources interconnecting to existing lines will require additional transmission circuit
- ◆ Avoid serving entire system solely from one zone
- ◆ Mitigations included in study cases for years beyond 2036 are highly dependent on location of future resources and area's load growth
  - Changes in location assumptions will change proposed mitigations identified in this study
  - Increased number of resource interconnections spread throughout the system can allow system redispatch as alternative mitigation for overload conditions during N-1 contingencies
- ◆ Load growth in Central 23kV and radial areas should be monitored to identify any additional or specific issues that arise
- ◆ Full utilization/flexibility of distributed utility-scale resources requires additional transmission upgrades. Further study required to identify reliable re-dispatch of resources as an alternative to a subset of transmission upgrades. Future investments required in technology and communications to support operations in order to perform more complex dispatches.
- ◆ DER technology will need to evolve by 2040 in order to provide stable, reliable grid services to be viable mitigations to system overloads.





# High Load Study (In Progress)

## ◆ Study Approach

- Use Peak Load from High Load data set
- Reference Evening Peak case → Peak load values are associated with evening hours (Hr19 and Hr20)
- High load case years are selected based on difference in load and difference in resources, in comparison to base case data

## ◆ Case Years

- 2028: Load similar to Base 2036 case
- 2031: New resource additions that were not captured in base analysis
- 2036: Higher load than 2050 base case + 50MW of additional resources than base analysis

Base Load	Base Additions	Installation/Removal Year	Install	Remove	Peak_Load
		2024	67.2	0	207.347
		2025	75	-2.52	214.5293
		2026	0	-6.61	221.6775
	211	2027	227.96	-111.83	231.6398
207		2028	0	0	233.1661
		2029	56.43	0	248.353
		2030	22.86	-40.5	257.0864
		2031	0	0	266.3022
		2032	0	0	275.2263
		2033	0	-42	285.7113
		2034	0	0	294.9319
	103	2035	153.96	0	304.2207
237.3		2036	0	0	312.5305
		2037	0	0	320.8225
		2038	0	0	328.0178
		2039	0	0	334.8724
	61	2040	162.18	-5.74	339.6178
266.1		2041	0	0	342.3061

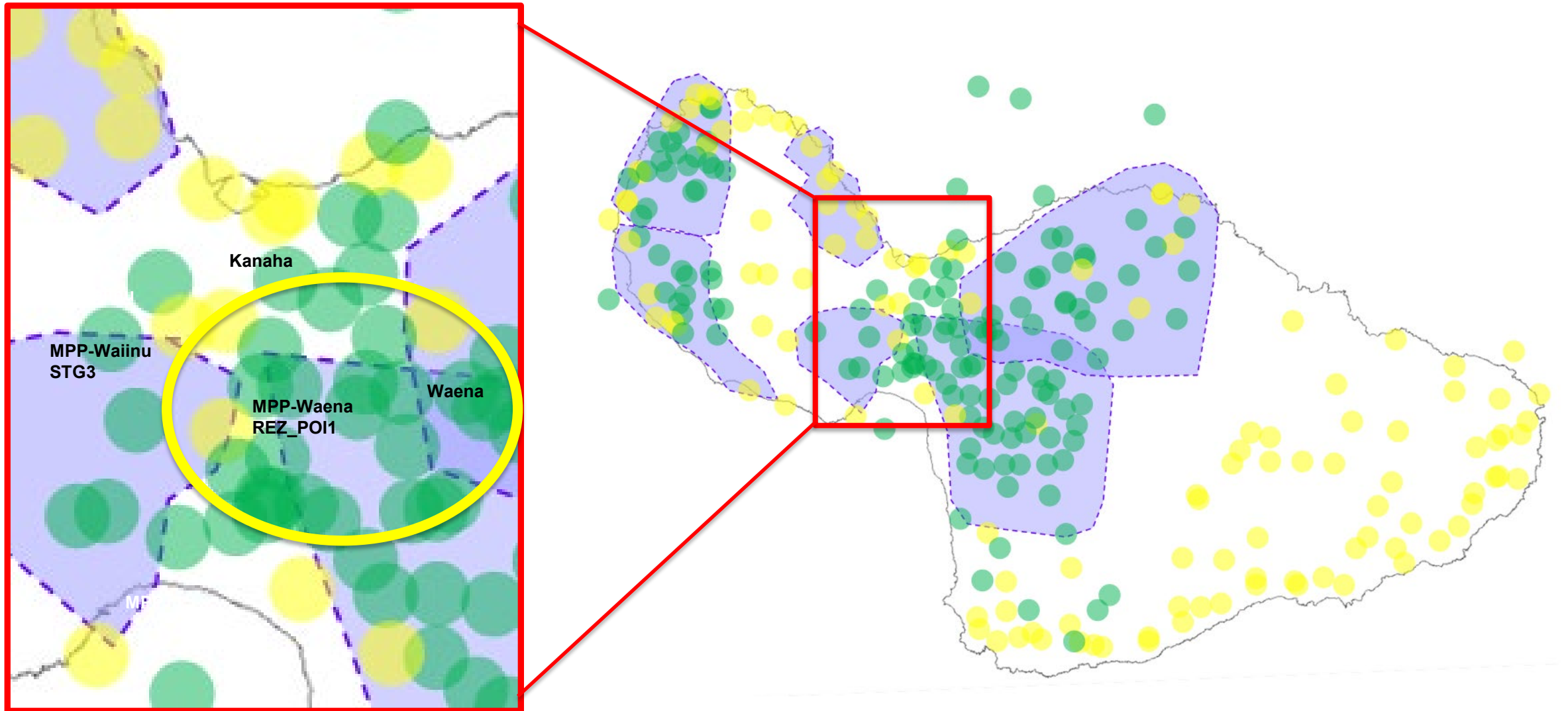




Mahalo for your time.

Any questions?

# REZ Map (for 2041 Selection)



# REZ Map (for 2046 Selection)

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