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Wind Curtailment, Mitigation Measures, and the Value of Storage on the Maui Grid

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ENG 505

U.S. DEPARTMENT OF ENERGY

NNSA

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CAVEAT

- The slides and discussion following represent work in progress, and are the result of preliminary analysis
- Request that you not distribute these slides outside of the Energy Systems class

Maui Grid Case Study

- 210 MW maximum load
  - 70 MW minimum
- Renewable Capacity
  - 72 MW of wind planned
  - 10 MW of biomass
- Conventional Capacity (diesel)
  - 30 MW of steam
  - 95 MW of reciprocating engines
  - 100 MW of combined-cycle

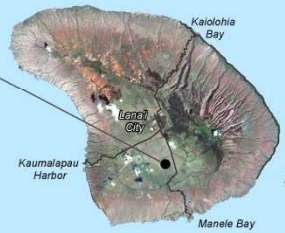
Map of Hawaiian Islands

Maui County Renewable Energy Map

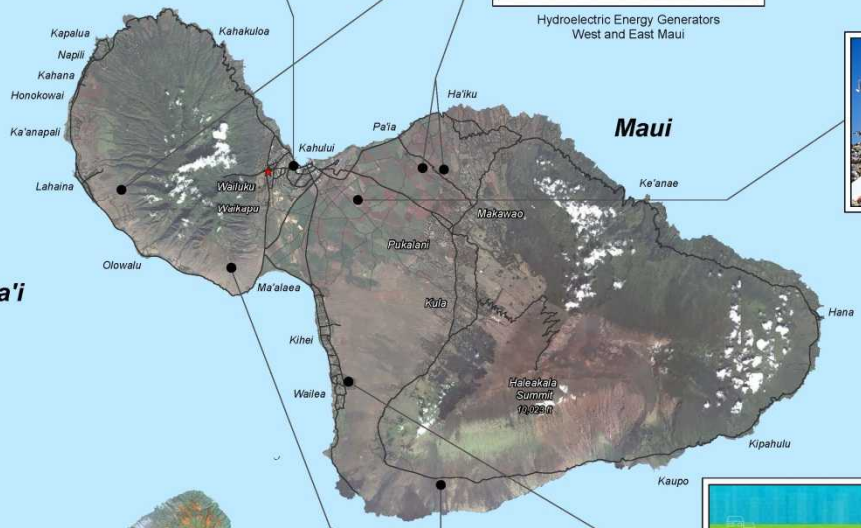
University of Hawai'i
Electric Car Charging Station Project

Hydroelectric Energy Generators
West and East Maui

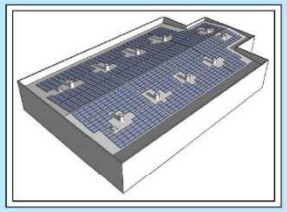
Government, Residential and Commercial Solar PV
Projects Makes up about 11 Megawatts of Power
for the Maui County Energy Grid and Continues to Grow



Lana'i



Methane Burning, Pu'unene Landfill



Kaho'olawe

Wind Energy, Kaheawa & Auwahi

Japan / U.S. Dept. of Energy Maui Smart Grid Project

Legend

Major Road

Street

★ County Building

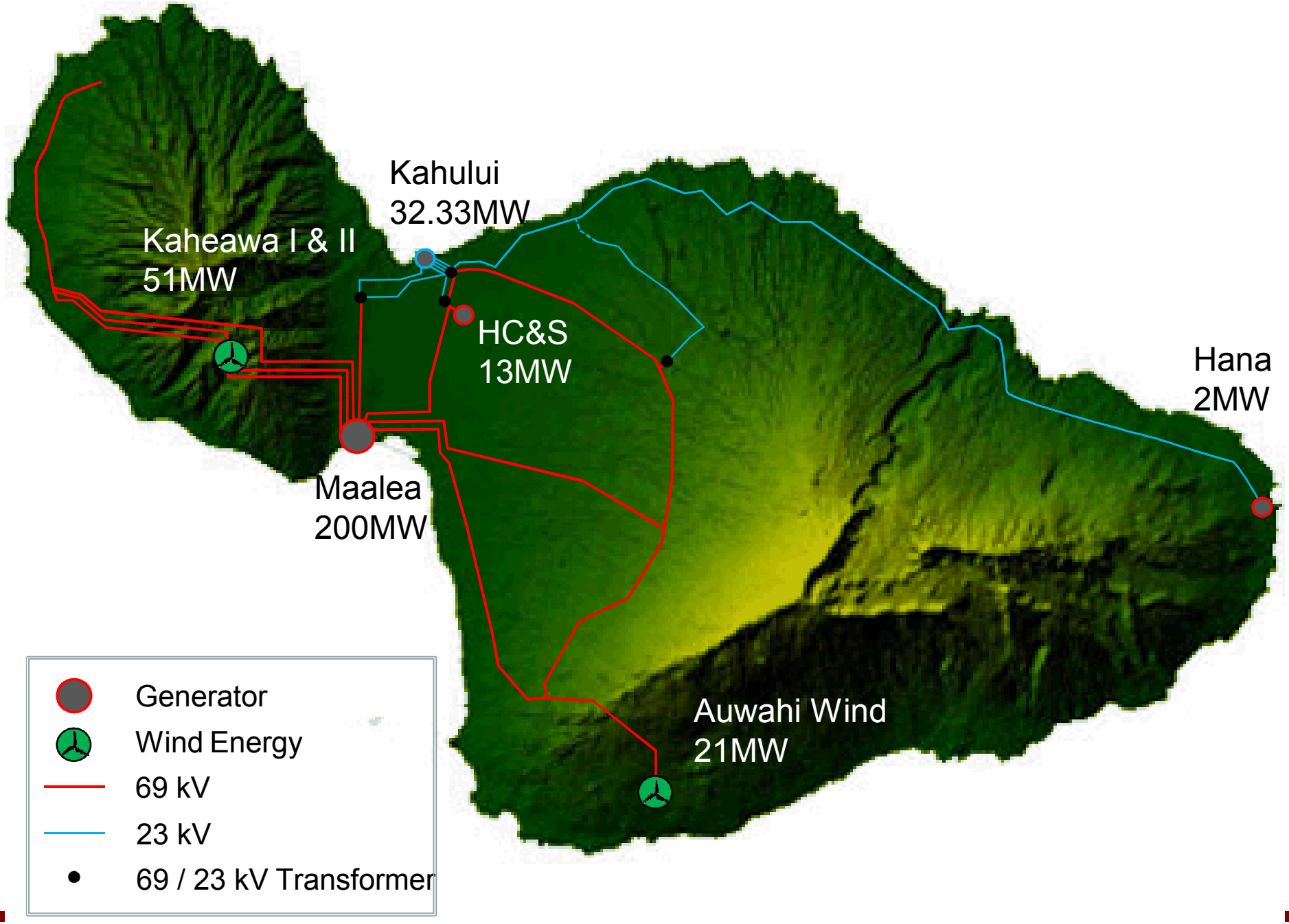
References:

Satellite Image: Digital Globe, 2005 & GeoEye IKONOS, 2004

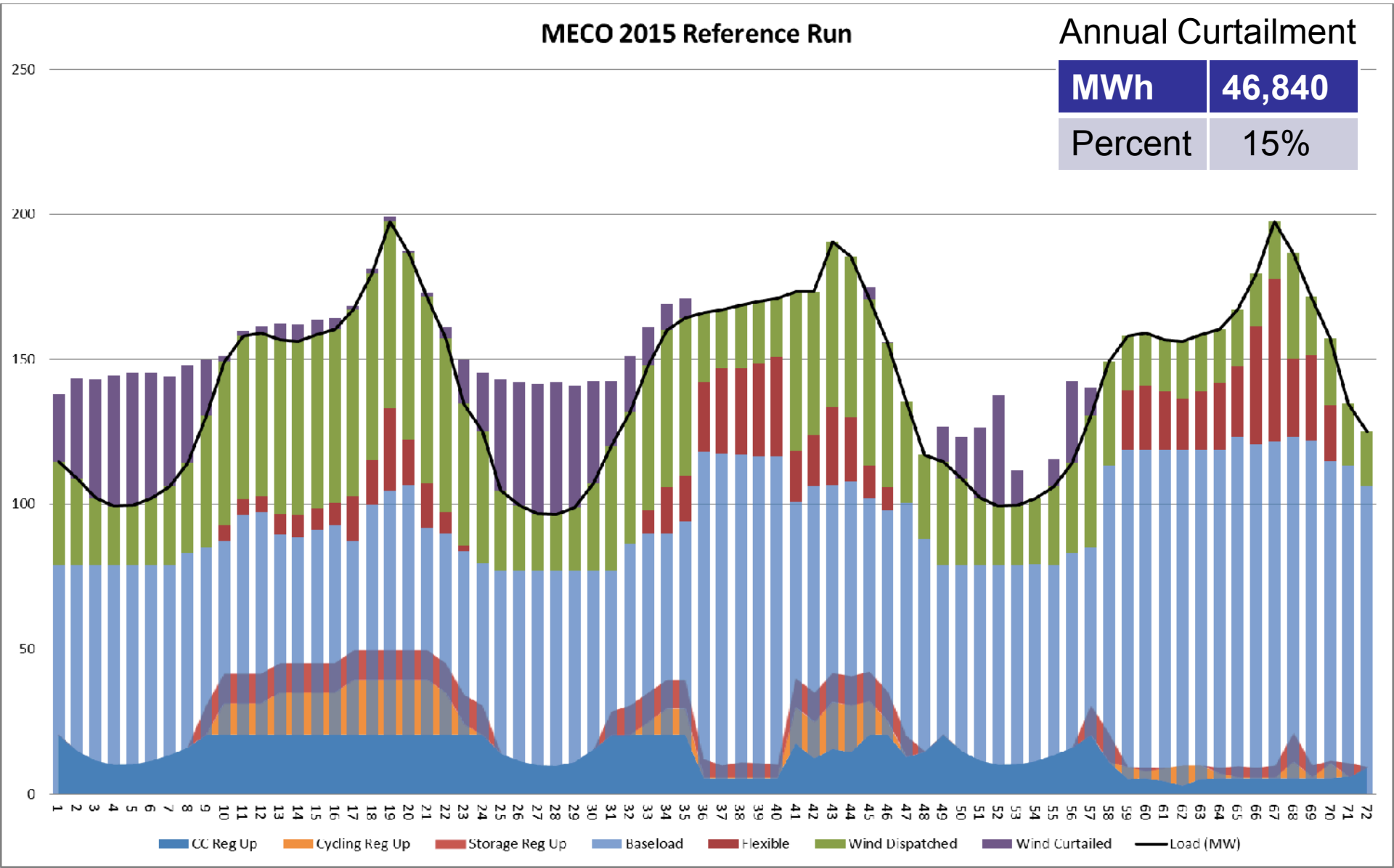
1:250,000

0 5 10 20 Miles

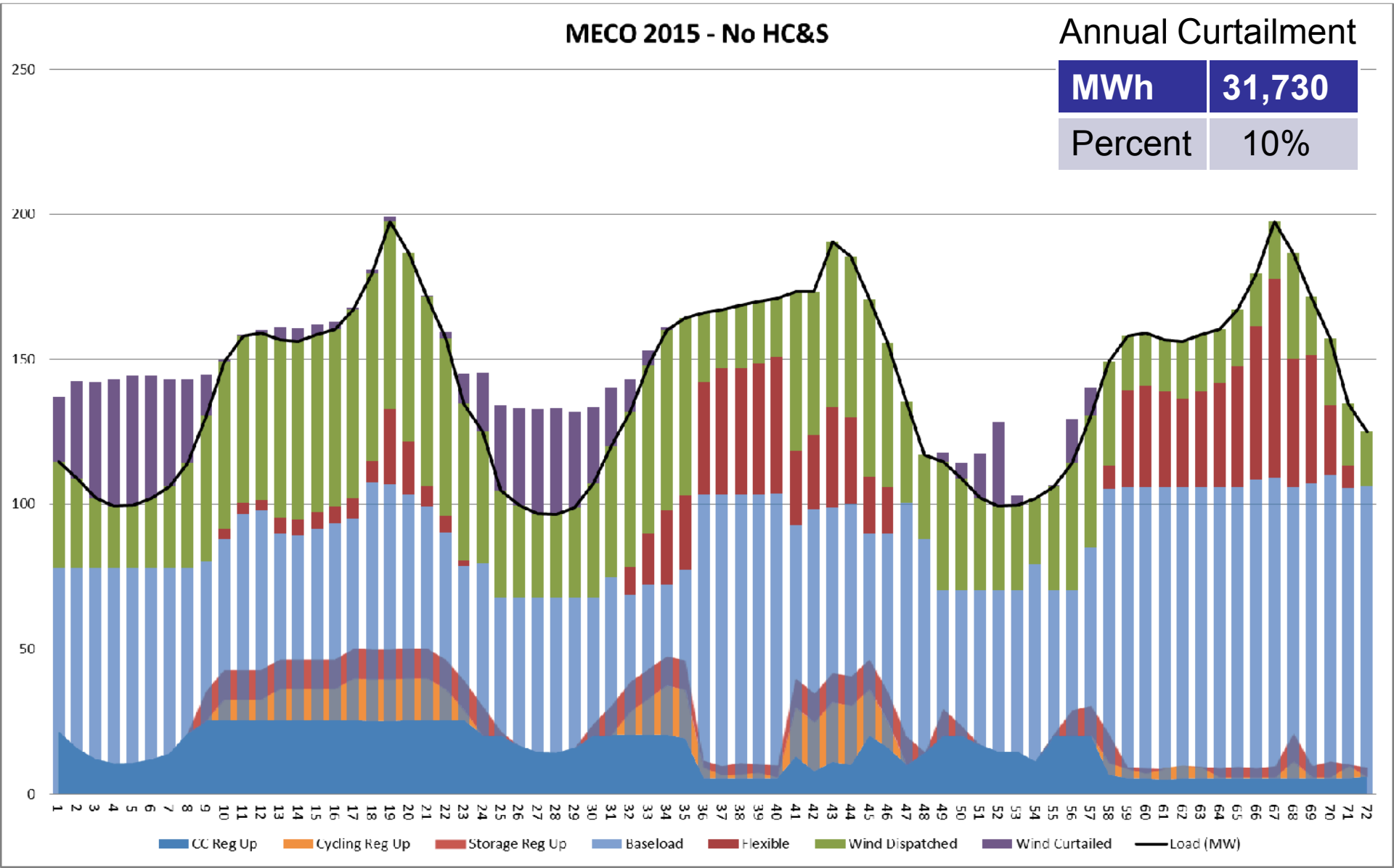
County of Maui
Department of Management
GIS Division
November 15, 2011


Kahului
32.33MW
Kaheawa I & II
51MW
HC&S
13MW
Hana
2MW
Maalea
200MW
Auwahi Wind
21MW
Generator
Wind Energy
69 kV
23 kV
69 / 23 kV Transformer

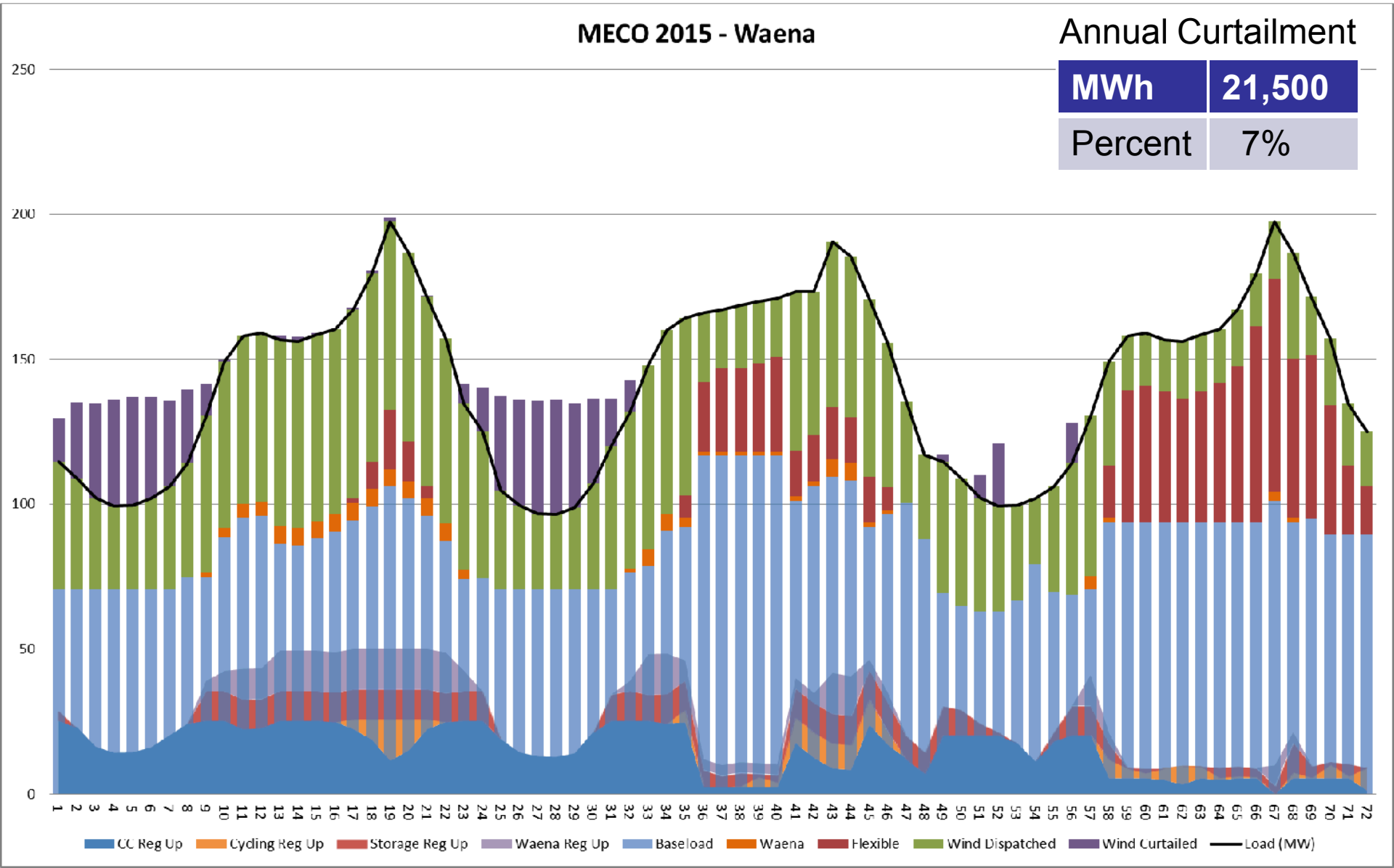
Reference Case 2015



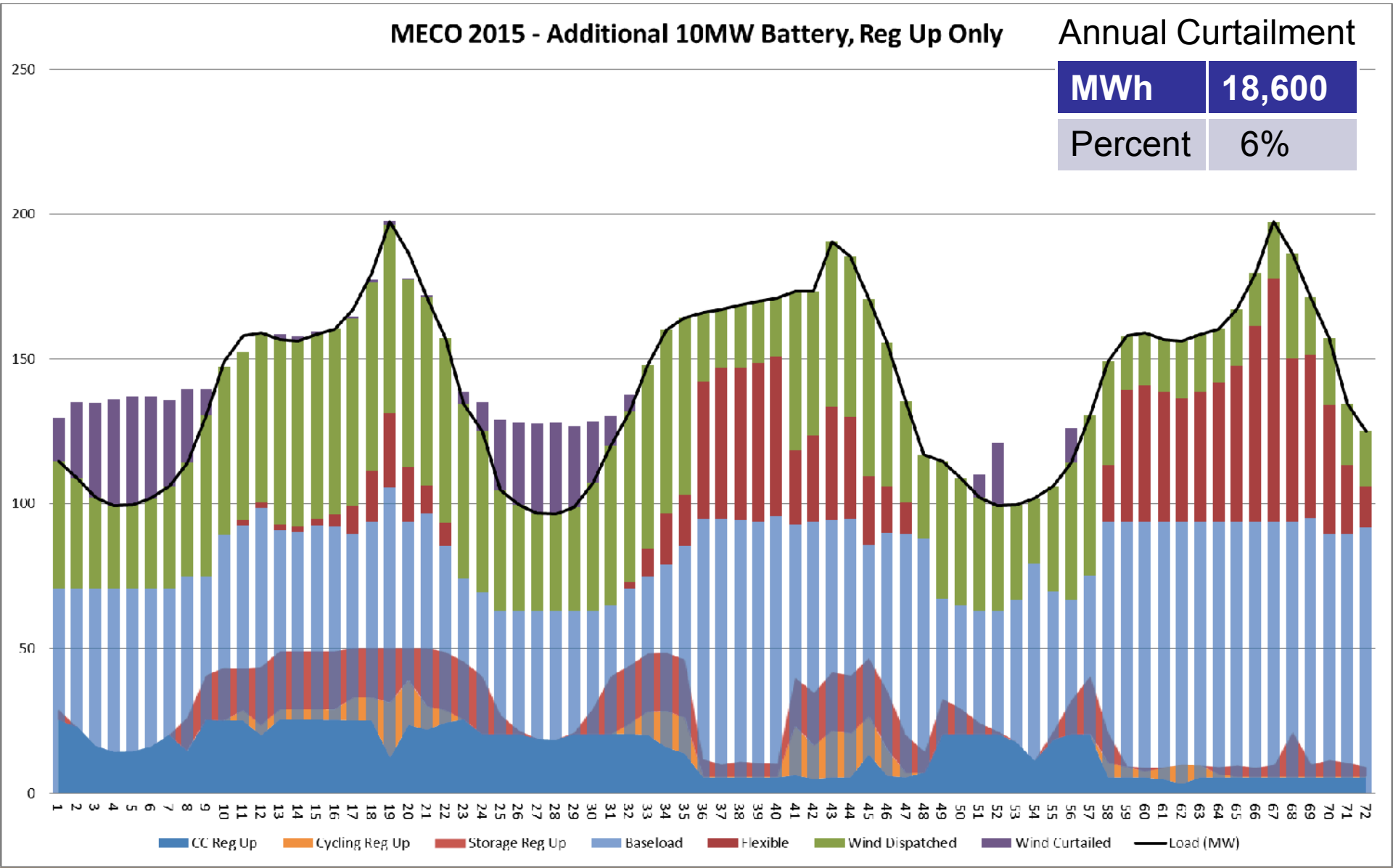
MECO 2015 – No HC&S



MECO 2015 – New Power Plant (no KPP)



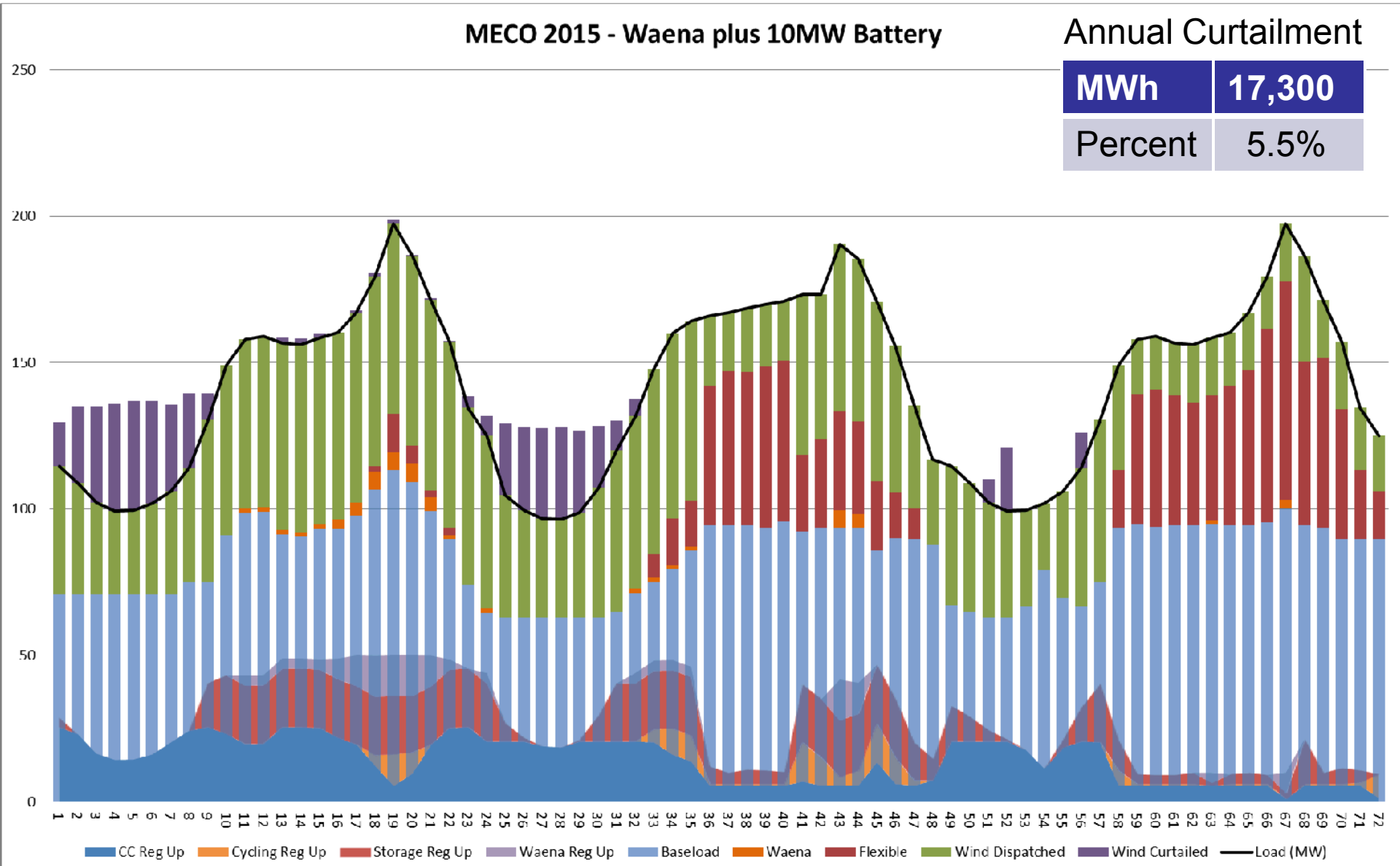
MECO 2015 – Extra 10 MW Battery



Annual Curtailment

MWh	18,600
Percent	6%

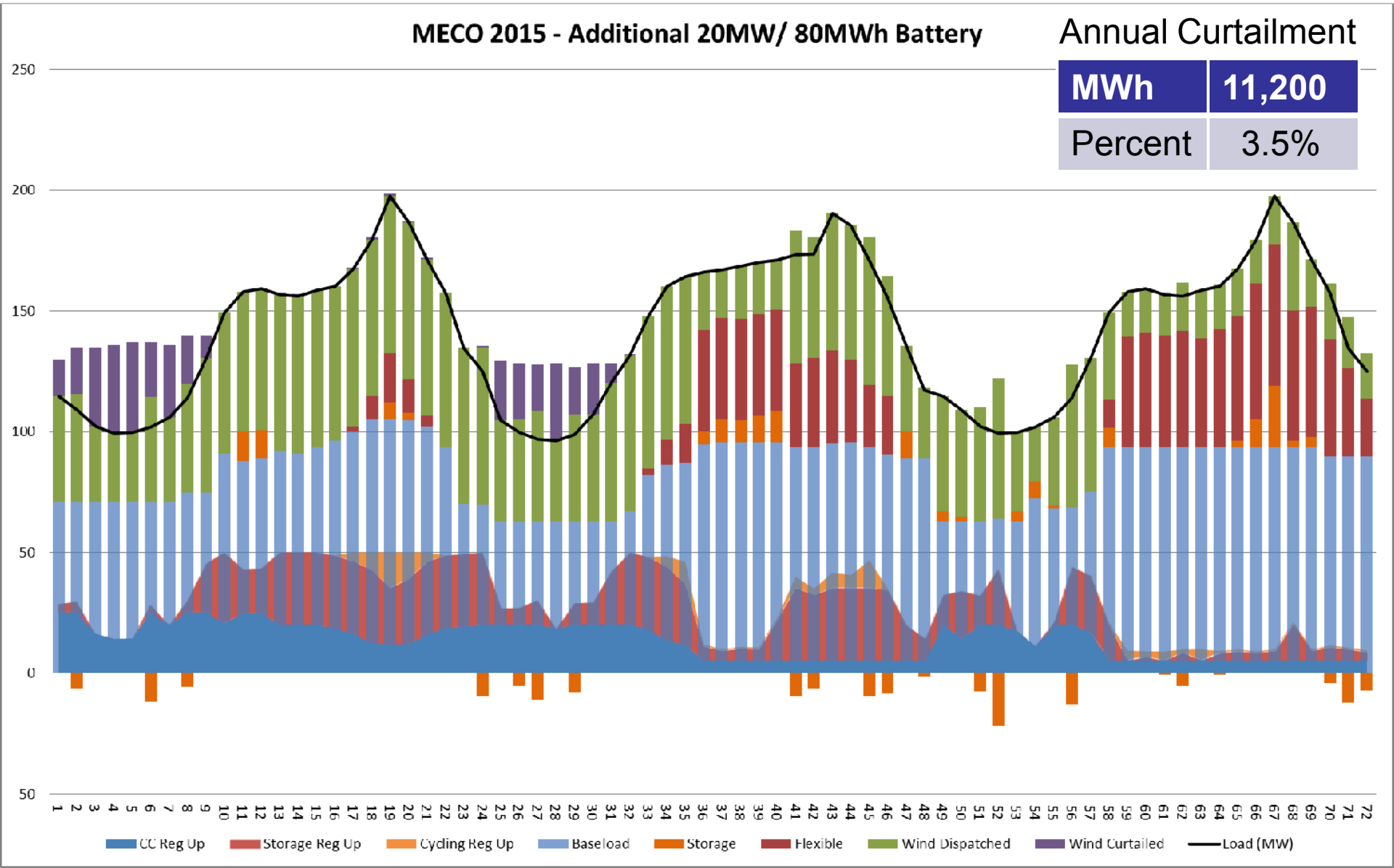
MECO 2015 –Power Plant + Battery



Annual Curtailment

MWh	17,300
Percent	5.5%

MECO 2015 – Large Battery



Annual Curtailment

MWh	11,200
Percent	3.5%

2015 Cost Comparison

Scenario Cost Comparison	Diesel Generation Cost	Difference	Cost of Additional Wind	Total Savings	Wind Curtailment Reduction
Reference	198,100	-	-	-	-
Kahului small BESS	190,300	7,800	3,600	4,200	9%
Kahului large BESS	184,200	13,900	4,600	9,300	11.5%
Waena	190,500	7,600	3,300	4,300	8%
Waena + Small K BESS	188,500	9,600	3,800	5,800	9.5%

Towards an NPV Calculation

Scenario Cost Comparison	Total Annual Savings	Value of Stream of Savings	Project Cost???	NPV???
Reference	-	-	-	-
Kahului small BESS	4,200	$36m (15-yr life)	$30m	$6m
Kahului large BESS	9,300	$80m (15-yr life)	$60m	$20m
Waena	4,300	$48m (30-yr life)	$30m	$18m
Waena + Small K BESS	5,800	$60m (15-yr/30-yr)	$60m	-

Discount value assumed: 8%
Remember: the stream of savings extrapolates the result of one year into the future.
Project cost number is speculative – so don't take NPV calculation seriously!

What is a Production Cost Model?

- Answers the question: What is the least-cost dispatch to meet load?
- Consists of an interface, and an optimization solver
  - Interface – allows input of unit characteristics, load data, etc.
    - This is used to construct an algebraic problem to solve
  - Solver – a commercial solver for solving large-scale mixed-integer optimization problems (CPLEX, Gurobi, etc.)
    - This solves the problem
- If we know the generator costs, why is this so complicated?
  - Optimizing for reserves as well as energy
  - Unit commitment decision
  - Dispatch of each unit decision
  - Variable generation requires a variable amount of reserves

What Studies are Possible?

- Solar / Wind Integration Studies
  - What variability in solar / wind causes the rest of the system to do
  - How much in renewables can you add without causing problems
- Evaluation of curtailment mitigation strategies
- Evaluation of benefits of storage, new generation, and transmission line projects
- Long-term integrated resource planning for utilities
- Could even be used to determine unit commitment / dispatch of a power system