Investigating Flexible Generating Capabilities at The Geysers

Geysers Power Company, LLC

December 03, 2015

California Energy Commission
(Grant # EPC-14-002)

CLEAN MODERN EFFICIENT FLEXIBLE POWER GENERATION

Agenda

1. Overview Of The Geysers Geothermal Field
2. Summary of Project Plans
3. Describe the Issues or Challenges the Research is Addressing
   Areas of Concern
4. Preliminary Results – too early to tell
5. Original Schedule – Revision to be determined
6. Impact of the High Valley Fire of September 12, 2015

The Geysers Overview
Calpine Corporation 2013 Facts

Calpine Geothermal Operations
- 29,000 acres (45 square miles)
- 14 geothermal power plants

Calpine Power Generation
- 2014 average load: 666.25 megawatts net
- 2014 generation: 5,836,16 net megawatt hours

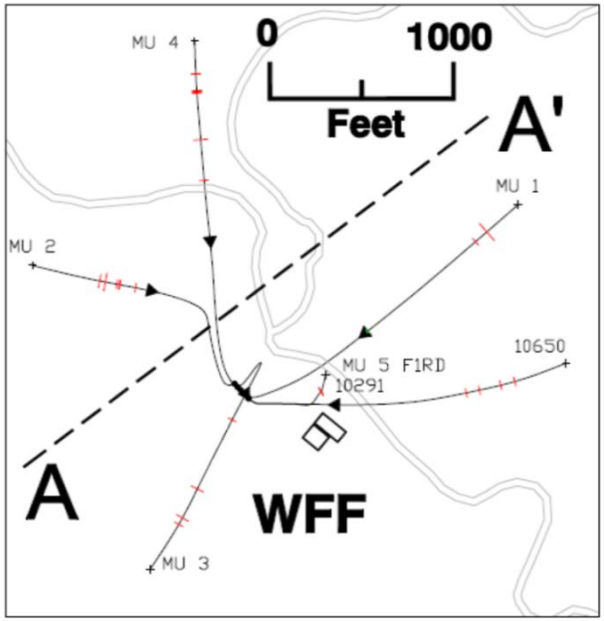
36% of United States
geothermal energy generation

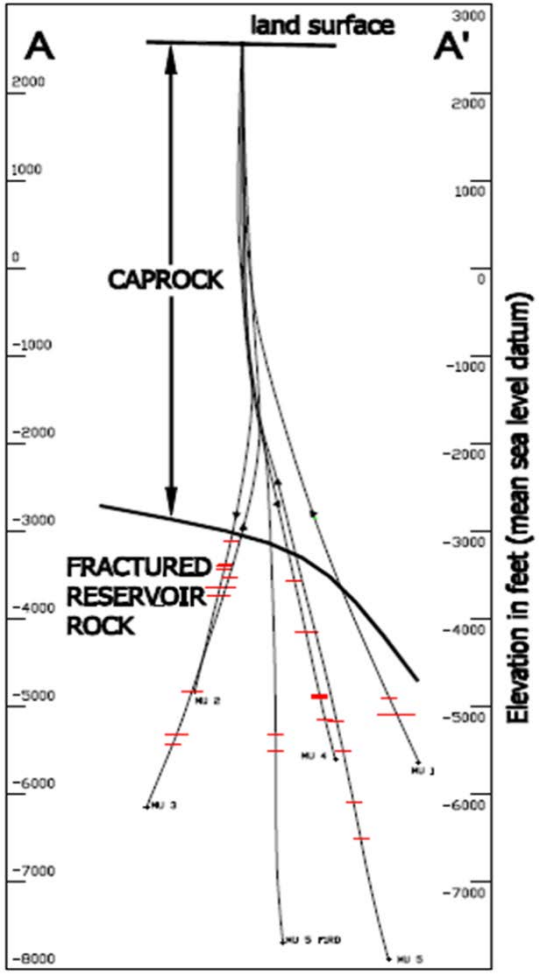
Cal Fire Report - Impact of Valley Fire

The Geysers Overview
Calpine Corporation 2013 Facts

Calpine Geothermal Wells

- 333 steam production wells - 60 water injection wells
- Average well depth: 8,500 feet (~ 2590 m)
- 2014 average steam production per well: 36,200 lb/hr
- Flow weighted average wellhead pressure: 79.2 psig
- Flow weighted average wellhead temperature: 362º F
- Flow weighted average wellhead enthalpy: 1216 Btu/lb
- Average reservoir rock temperature: 465º F,





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Goals and Objectives

- Goals:
  - Define flexible generation capabilities and limitations at the Geysers;
  - Avoid risks to geothermal facilities related to flexible operation; and
  - Determine costs associated with providing flexibility and ancillary services.

- Objectives:
  - Develop an integrated model that simulates flexible operation in wells, pipelines, power plants and throughout the Geysers steam field;
  - Conduct curtailment pilot tests in the Geysers steam field both around an isolated power plant, and at a location in which the steam field pipelines are cross-tied to several power plants;
  - Test mitigation strategies that will be needed to achieve flexible steam field operation;
  - Define the management strategy that will allow the Geysers to provide flexible capacity without posing significant risks to the reservoir, pipeline, wells, and power plants;

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Areas of Concerns

- Reservoir:
  - Cycling could change near wellbore behavior with effects in well deliverability.
- Wellbore:
  - Loss of wellbore superheat may lead to condensation. When the steam condenses, hydrogen chloride gas in the steam ionizes to hydrochloric acid and leads to localized corrosion of upper wellbore, wellhead equipment and tie-in piping
  - Steam condensation can lubricate rocks and cause sloughing and obstruction ("bridging") of wellbores which are not lined through the reservoir
- Steam Field:
  - Low steam flow in pipeline could increase the rate of heat loss in pipelines leading to steam condensation and potentially corrosion
- Power Plants:
  - Non-condensable gases (NCG) can form gas slugs in low velocity sections of pipeline, such as cross-ties, that can overwhelm a power plant's gas removal system, or cause abatement system instability and/or unit trips.
  - Variation in gas chemistry can affect abatement system operation.
- Operations/Other:
  - Accurate steam flow rate metering is a critical challenge during deep flow rate cutbacks

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Project Tasks

- Task 1, General Project Tasks
- Task 2, Develop an Integrated Production Model for the Geysers under Flexible Generation:
  - Develop modeling methods and tools for optimization of steam fields and power plants for flexible generation at the Geysers
- Task 3, Pilot Test Flexible Generation Scenarios and Field Management Tools:
  - Test various flexible generation scenarios;
  - Collect and provide data to assist with model validation.
- Task 4, Determine Field Management Strategies :
  - Define the limits of flexible operation
- Task 5, Evaluation of Project Benefits
- Task 6, Technology/Knowledge transfer

Investigating Flexible Generating Capabilities at The Geysers
Preliminary Results as of 10/31/2015.

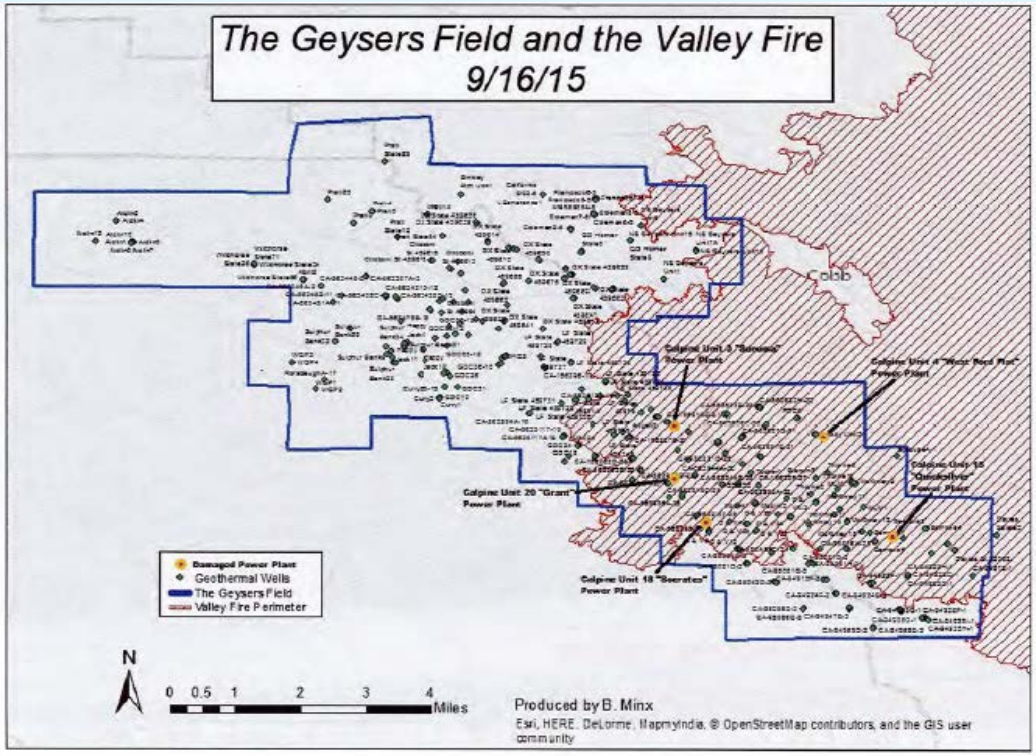
Task Description	Status	Start	Finish
Task 1 : General Project Tasks	Ongoing	7/1/2015	11/30/2015
Task 1.10: Technical Advisory Committee (TAC)	Completed	4/1/2015	9/30/2015
Task 2.1 : Evaluate existing analytic and simulation models	Ongoing	4/1/2015	?
Task 2.2 : System component modeling	Ongoing	7/1/2015	?
Task 3 : Pilot Testing – Steam Turbine Bypass Feasibility Study	Ongoing *	10/1/2015	?
Task 3.1 : Develop Field Testing Plan and Define Test Protocol	Suspended	4/1/2015	?
Task 3.2 : Phase I - Individual well and component testing	Suspended	7/1/2015	?
Task 4 : Determine Field Management Strategy	Suspended	?	?
Task 5 : Project Benefits	Ongoing	4/10/2015	?
Task 6 : Technology Transfer	Suspended	?	?

Deliverables Schedule – TBD

As originally proposed
Update schedule TBD

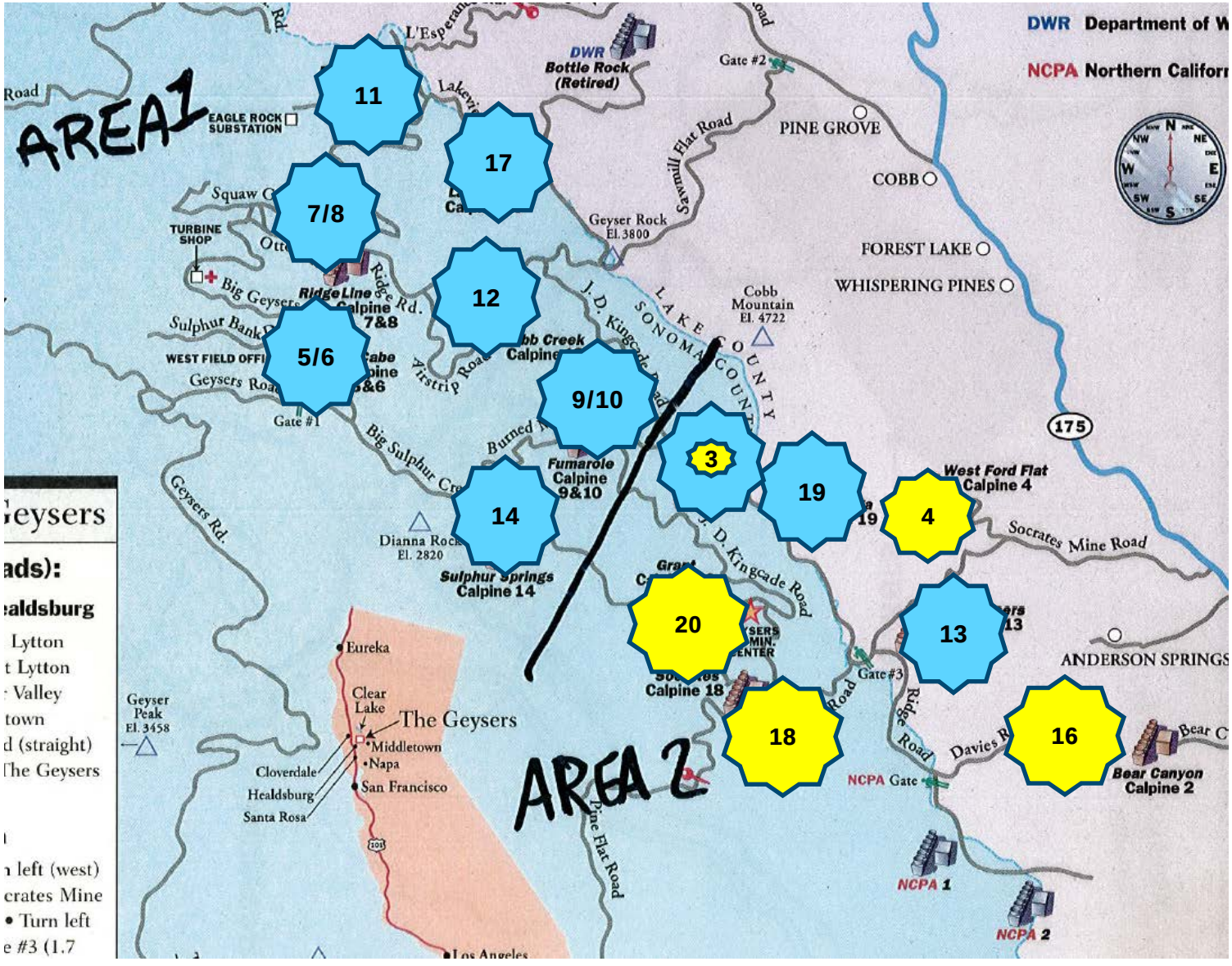
- Final Report:
  - Draft final report outline: 1/31/2017
  - Final report outline: 2/28/2017
  - Draft final report: 5/30/2017
  - Final report: 6/30/2017
  - Final Technology/Knowledge Transfer Report: 8/31/2017
- Critical Project Review (CPR) meetings:
  - CPR meeting #1: Soon
  - Task 2: CPR meeting #2:
    - Integrated Model Report: 12/31/2015
    - CPR Report #1: 12/31/2015
  - Task 3: CPR meeting #3:
    - Load Following Test Plan: 12/31/2015
    - Pilot test report: 12/31/2016
    - Updated integrated model report: 12/29/2016
    - CPR report #2: 12/29/2016
  - Task 4: CPR meeting #4:
    - Field Management Strategy for Flexible Operation: 6/30/2017
    - Matrix of Flexible Operating Characteristics: 6/30/2017

Valley Fire Damage



II. Valley Fire Summary Information

The Valley Fire began on September 12, 2015 and burned 76,067 acres in Lake, Sonoma, and Napa Counties, south of Clear Lake (Figure 1). Major areas impacted include Middletown, Cobb, and Hidden Valley. Tragically, the fire killed four people. Additionally, a total of 1958 structures were destroyed, including 1280 homes and 27 apartment buildings. This total makes the Valley Fire the third worst in state history in terms of the number of damaged structures. Approximately 99 percent of Boggs Mountain Demonstration State Forest rapidly burned (roughly 3460 acres of the total Forest area of 3493 acres). The Valley Fire area burned went from 400 acres in the first few hours to 40,000 acres in approximately the first 18 hours due to high wind conditions, reported up to 60 mph. Detailed information is provided at: http://cdfdata.fire.ca.gov/incidents/incidents_details_info?incident_id=1226



DWR Department of W
NCPA Northern Californ
AREA1
AREA 2
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17
7/8
12
5/6
9/10
3
19
4
14
20
13
18
16
DWR Bottle Rock (Retired)
EAGLE ROCK SUBSTATION
TURBINE SHOP
Ridge Line Calpine 7&8
WEST FIELD OFFI
Gate #1
Gate #2
Gate #3
Geyser Rock El. 3800
Cobb Mountain El. 4722
PINE GROVE
COBB
FOREST LAKE
WHISPERING PINES
LAKE COUNTY
SONOMA COUNTY
Fumarole Calpine 9&10
Sulphur Springs Calpine 14
West Ford Flat Calpine 4
Socrates Mine Road
Dianna Rock El. 2820
Calpine 18
ANDERSON SPRINGS
Bear Canyon Calpine 2
NCPA Gate
NCPA 1
NCPA 2
Eureka
Clear Lake
The Geysers
Middletown
Napa
San Francisco
Cloverdale
Healdsburg
Santa Rosa
Geyser Peak El. 3458
Los Angeles
Big Sulphur Cre
Geysers Rd.
Sawmill Flat Road
Ridge Road
Davies R
Pine Flat Road
J. D. Kingcade Road
Airstrip Road
Big Geysers
Sulphur Bank
Geysers Road
Squaw C
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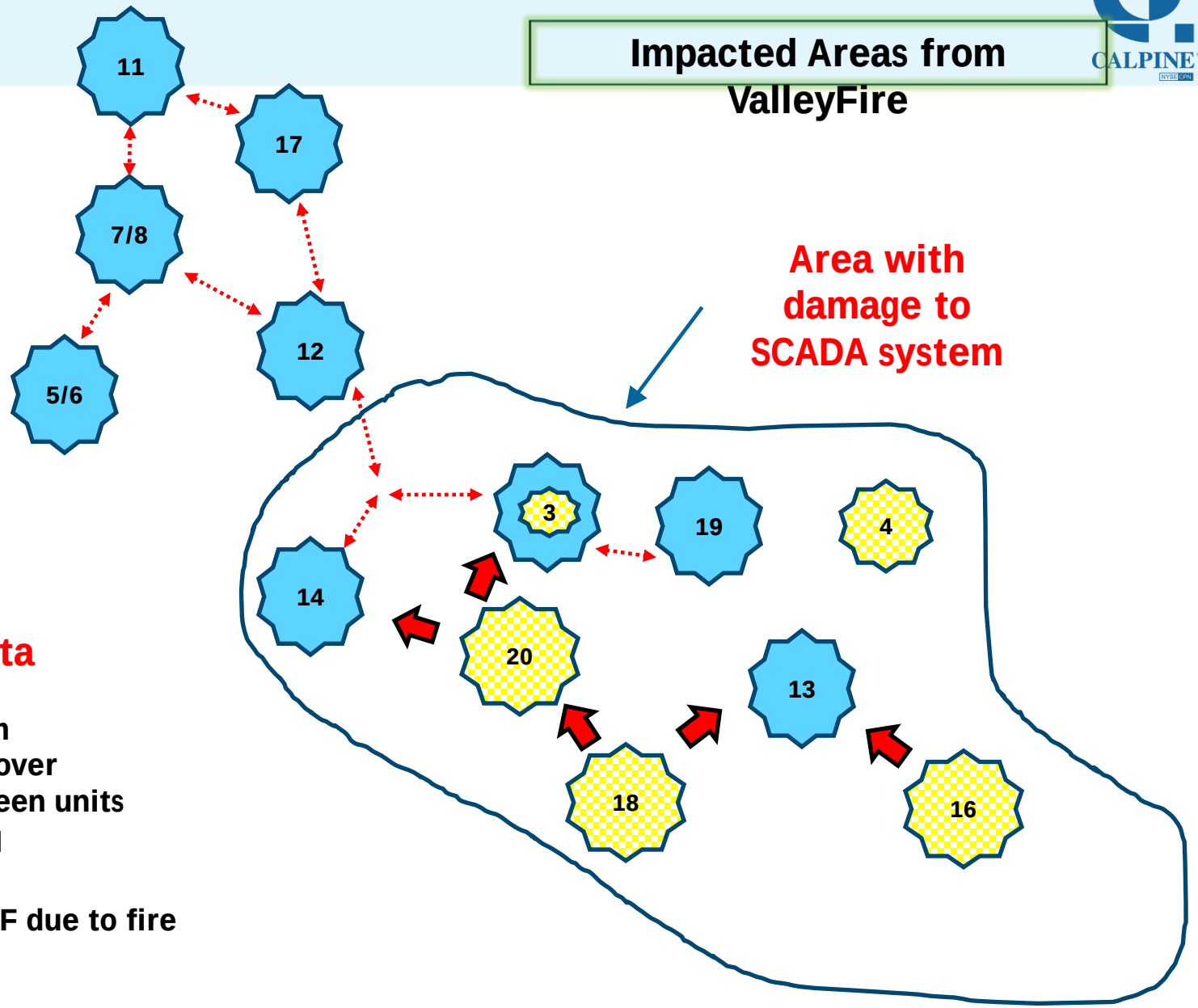
L'Esperan
175

Impacted Areas from ValleyFire



SCADA = Supervisory Control & Data Acquisition

Steam crossover between units

Plant ON

Plant OFF due to fire damage

Steam rerouted

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