A/C Stalling at SCE

DOE Workshop
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Problem Definition

- Necessary system conditions:
  - High temperatures which cause high A/C usage
  - High electrical system loading
  - Electrical system fault (failed component, lightning strike, car hitting pole, etc)
- Fault (short circuit) causes low voltage in area until cleared (3 to 30 cycles)
- Low voltage stalls air conditioners and some loads disconnect themselves
- High reactive power draw from stalled A/C units keeps system voltage depressed for up to 35 seconds
- A/C compressors disconnect themselves with thermal protection switches
- Voltage recovers and air conditioners restart
Typical A/C Stall Event (230 kV)

- Voltage Deviation (%)
- Time

- 6% to 21% Voltage Deviation
- 20 Sec. Time
- Fault & Fault Clears
- Delayed Recovery As Stalled A/Cs
- Disconnect Via Thermal Protection Switch
- Capacitors Off Due To Over-Voltage
- A/C Load Coming Back
- Overshoot Due To Capacitors Still On Line
- Under-Voltage Due To Capacitors Off Line (exposure to another event)
Typical Electrical System

- Transmission system feeds power into major regional load centers
- Sub-transmission feeds power to distribution substations
- Distribution feeds final customers
Why Are We Concerned?

- Undervoltage event could lead to total system voltage collapse
  - Modeling work to better define
- Presents voltage sag to all customers in the area
  - Power quality issue for all customers
- Getting worse as more homes with air conditioners are built in warm inland areas
Delayed Voltage Recovery Events at SCE

- 1988 & 1989 – First delayed voltage events observed at SCE (Devers and Antelope)
- 1990 – Valley (June)
- 1997 – Lugo plane crash – lost 3500 MW (8/5)
- 2004 – 4 events at Valley/Devers
- 2005 – 3 events at Valley/Devers
- 2006 – 37 events at Valley, Devers, Antelope, Rector, Villa Park
- 2007 – 6 event at Rector, Antelope, Valley
Increasing Air Conditioning Usage

**Air Conditioning by Dwelling Age**

- **Before 1975:** 17% Homes with CAC (includes multiple systems), 29% Homes with Evap or RAC
- **1975-1978:** 54% Homes with CAC (includes multiple systems), 12% Homes with Evap or RAC
- **1979-1983:** 54% Homes with CAC (includes multiple systems), 11% Homes with Evap or RAC
- **1984-1991:** 70% Homes with CAC (includes multiple systems), 5% Homes with Evap or RAC
- **1992-2000:** 76% Homes with CAC (includes multiple systems), 2% Homes with Evap or RAC
- **2001-2003:** 77% Homes with CAC (includes multiple systems), 1% Homes with Evap or RAC

**Source:** California Energy Commission, California Statewide Residential Appliance Saturation Survey
Number of A/C Units at SCE

2003 Study

- 2.2 M Central A/C (4.5 M customers)
  - ~ 7000 MW at peak
- 1.0 M Window A/C
  - ~ 1000 MW at peak
- 2003 System Peak Load ~ 20,000 MW
- A/C ~ 40% of load on peak
California A/C Load at Peak

California Daily Peak Loads -- 2006

Residential Air Conditioning
Commercial Air Conditioning

35% of Peak Load is A/C

Source: California Energy Commission
Coastal Load

Peak Load ~ 600 MW

25% of Peak Load is A/C
Inland Load

Peak Load ~ 1,500 MW

60% of Peak Load is A/C

2.4X
What’s Being Done

- A/C tests done to obtain better A/C system performance data
  - SCE, BPA, and APS/EPRI
- WECC working on A/C load modeling project to more accurately model A/C stalling effects (CEC $’s)
- Evaluating mitigation measures
  - Electric System level
  - A/C Unit level
- Engaging A/C Industry, Utilities, DOE, and regulatory bodies to develop comprehensive national solutions
Actions Underway

- Manufacturers
  - Help identifying best solutions
  - Work with Air-Conditioning, Heating and Refrigeration Institute (AHRI)
  - Prefer national measures, not state-by-state

- Utilities
  - Gather group of interested utilities to support actions
Actions Underway

- **DOE**
  - This workshop…

- **California Energy Commission**
  - Fund research on models

- **Legislative/Regulatory**
  - Investigating how to develop new standards
    - Federal level best to address national problem
    - Appliance efficiency standards
    - Rebate programs
    - Other ideas
Long-Term Solution

- New air conditioner standard is needed; e.g.:
  “Any air conditioner shall include features which prevent the compressor from remaining connected to the electrical supply system in a stalled condition for more than {one-tenth?} of a second.”

- An A/C standard would keep the future situation from getting worse

- Large number of existing A/C units means retrofit might be necessary

- Need a combination of approaches (standards, retrofits, system)
Electric System Level Measures

- Use new models to study:
  - Speed of voltage collapse
  - If system level devices (SVC, Statcom, Sync Condensers) can help prevent voltage collapse

- SCE has recently installed SVCs and HV capacitors for system needs and is evaluating their performance in addressing the problem
Assessment of Electric System Level Measures

- Cannot prevent faults from occurring nor A/C units from stalling
- System level solutions (e.g. SVC, Statcom) should:
  - Reduce the size of the area affected
  - Reduce the length of stall events
- Could be very costly
  - Would need a number of devices throughout the SCE system
  - A large SVC costs $20M to $50M each
Summary & Next Steps

- A/C Stalling problem is complicated and will take time to solve
- Many possible solutions, all have challenges
- Actions are being taken on all fronts:
  - Use system solutions wherever practical to prevent voltage collapse
  - Determine how to deal with existing population of A/C units (are retrofits necessary?)
  - Pursue standards or other methods to prevent the problem with new A/C units (limit growth of problem)
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