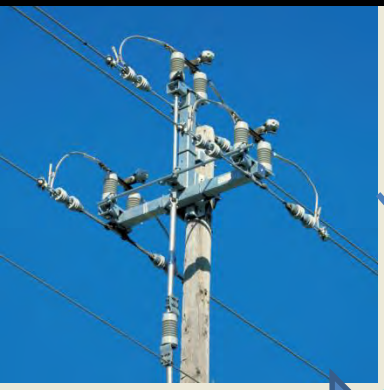
The Old Grid vs. The Smart Grid
The Economic Impact on the Electricity Customer

S&C Electric Company

OLD GRID

How do things unfold in the Old Grid World? Let's find out…



X=12000, Y=6000

7/26/2012 12:57 PM

OLD GRID

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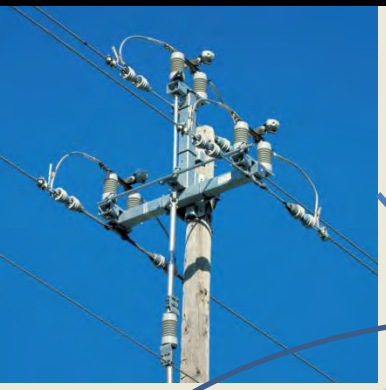
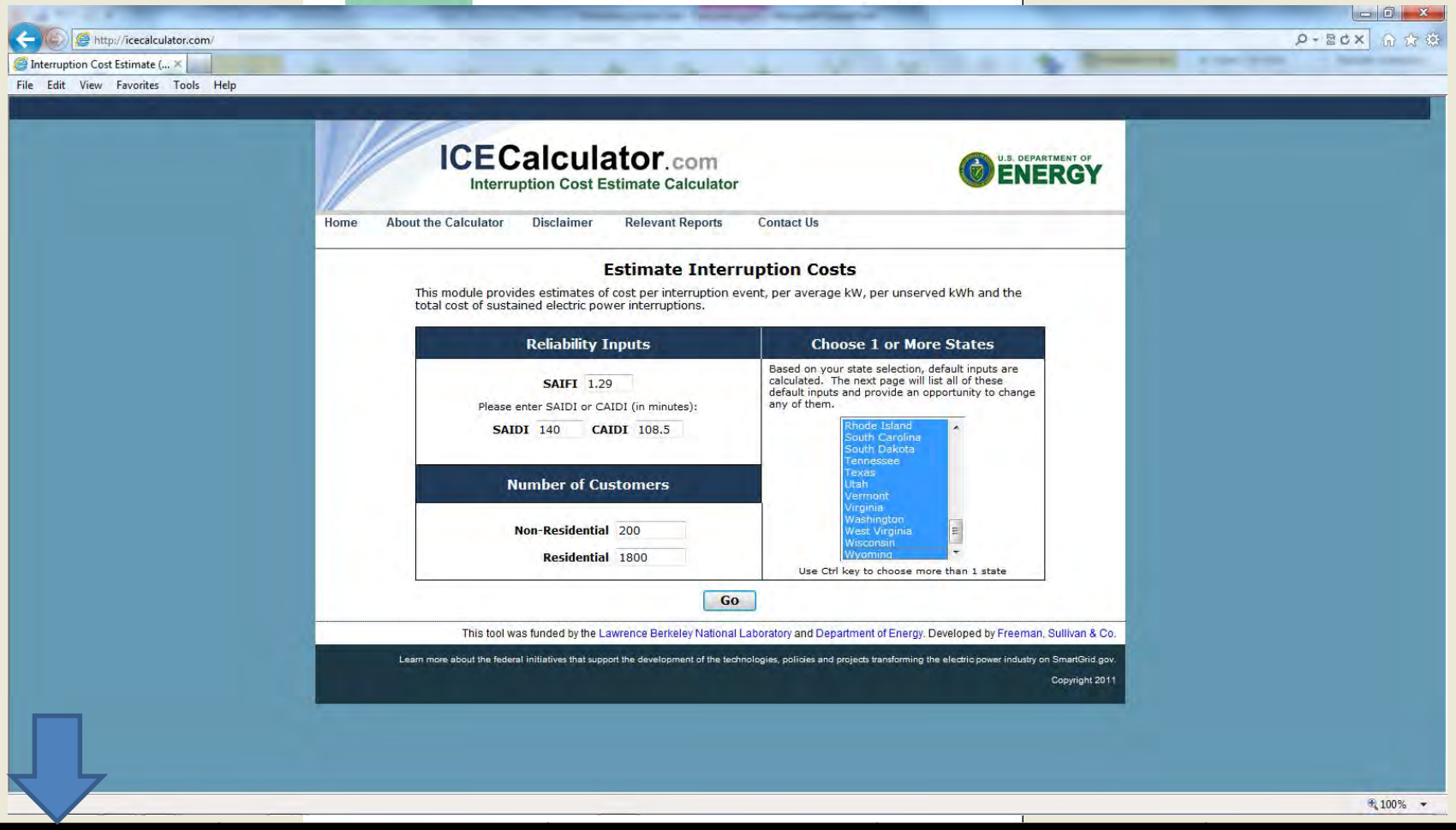


X=12000, Y=6000

OLD GRID

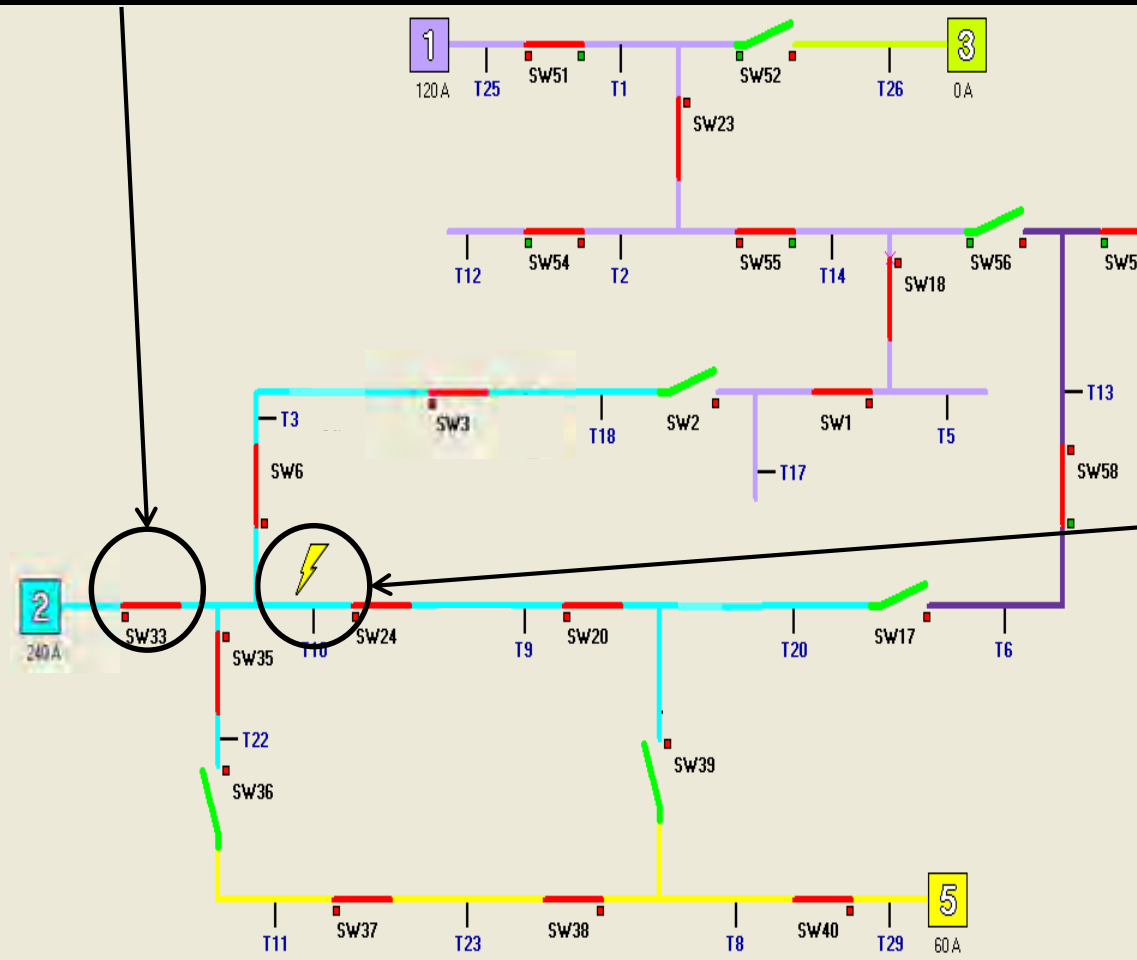
How do things unfold in the Old Grid World? Let's find out…



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
0	0	0	0	$0

OLD GRID

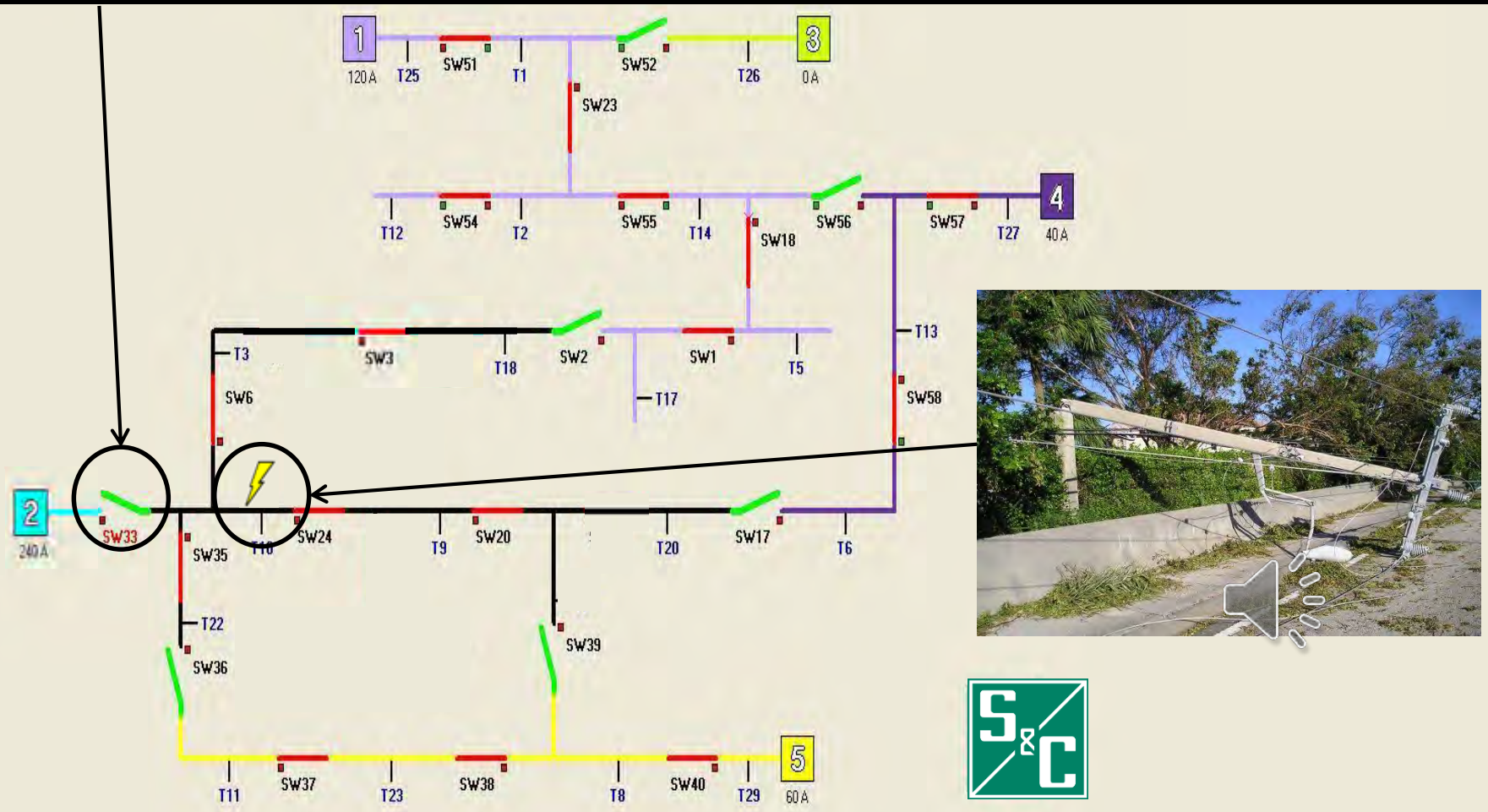
Circuit Breaker 33 – trips open



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
0	0	0	0	$0

OLD GRID

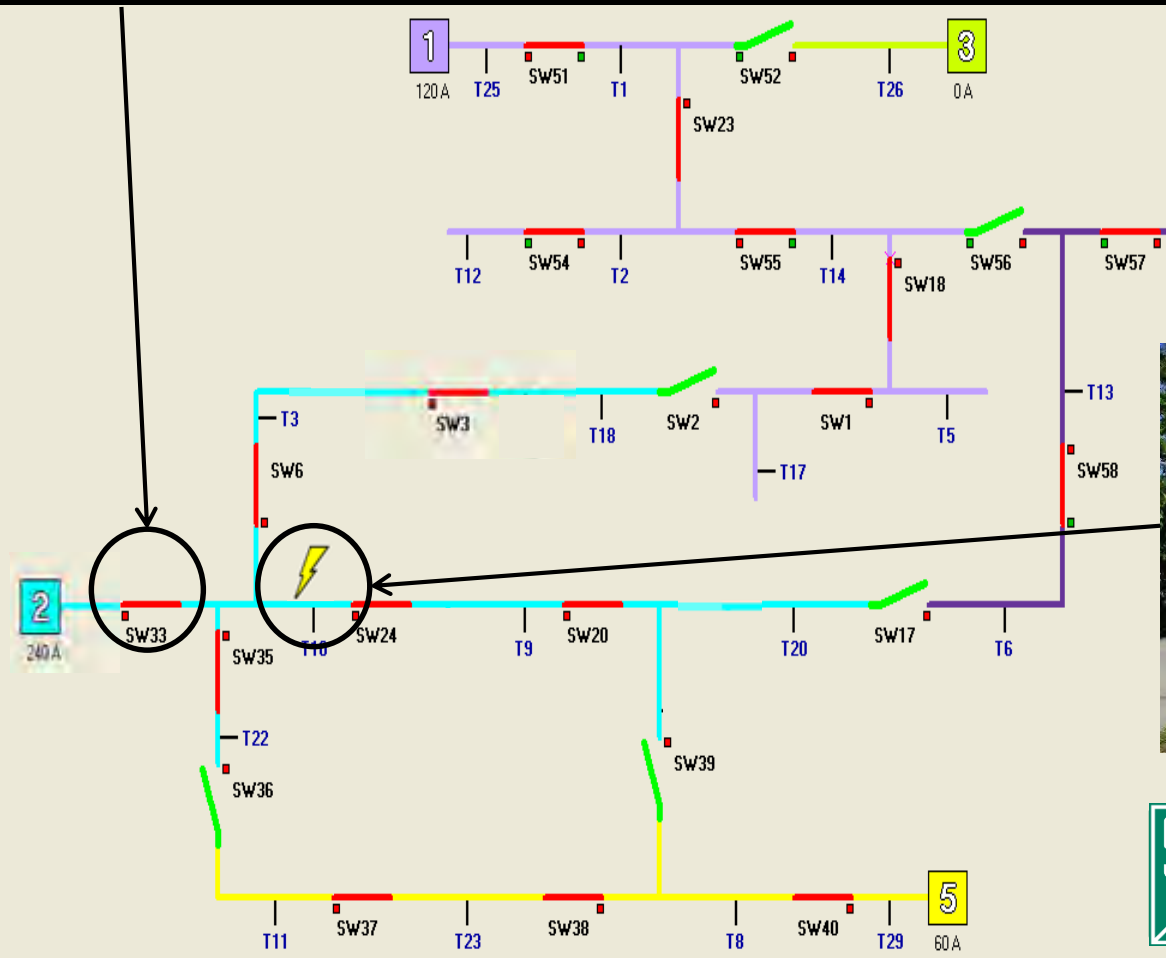
Circuit Breaker 33 – trips open



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
0	2,000	0	0.0	$92,474

OLD GRID

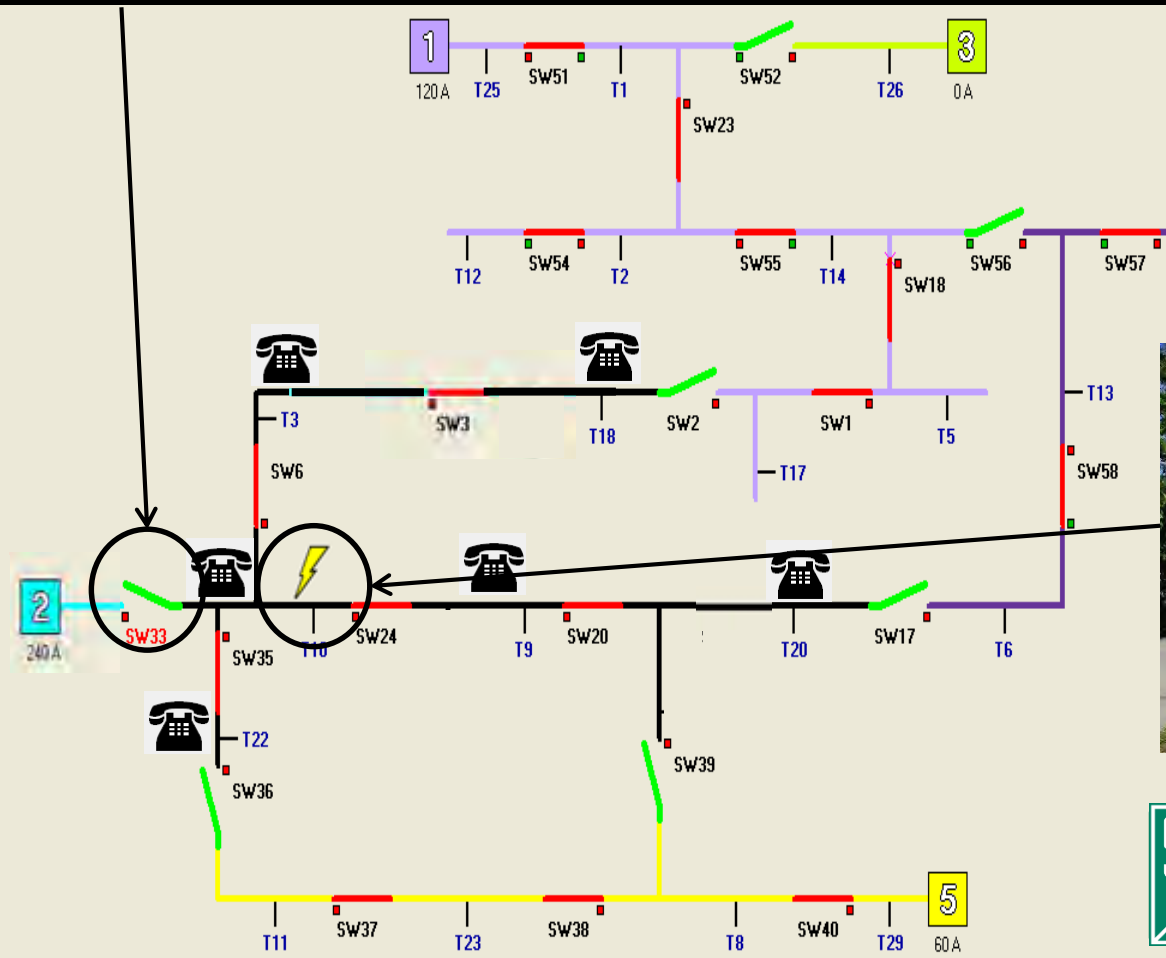
Circuit Breaker 33 – recloses anticipating a temporary fault (eg. animal contact)

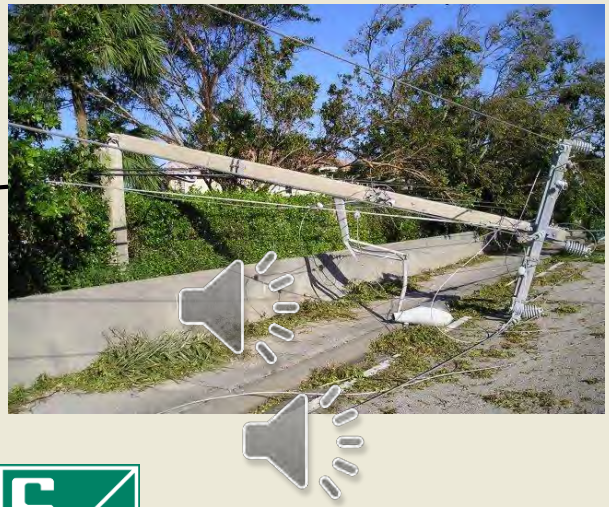


Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
0	0	0	0.0	$92,474

OLD GRID

Consumers phone in power is out and Outage Management assesses extent of outage.

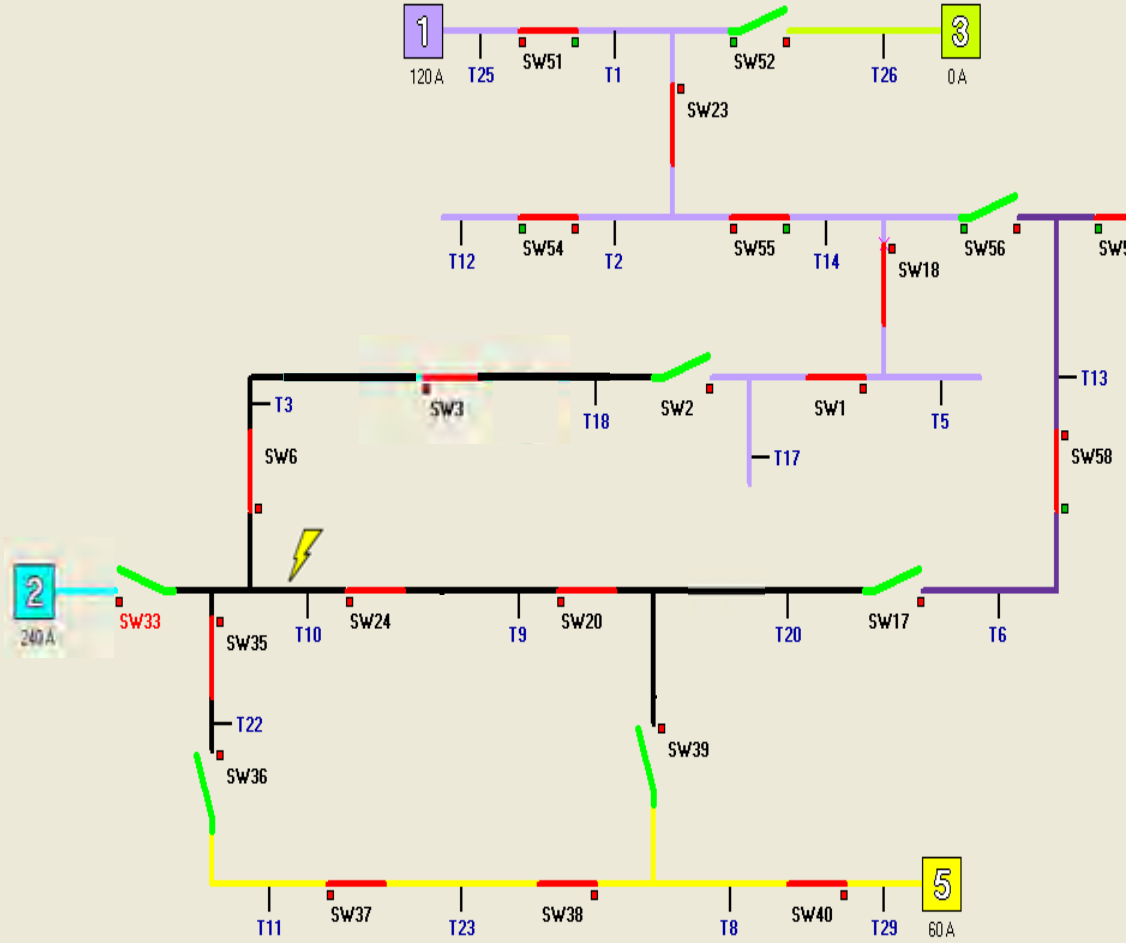


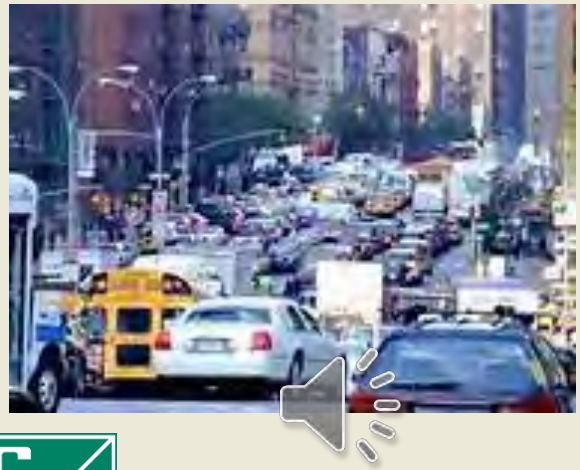


Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
8	2,000	15,943	8.0	$108,663

OLD GRID

Extensive outage means traffic lights are inoperable. Slow progress towards feeder.

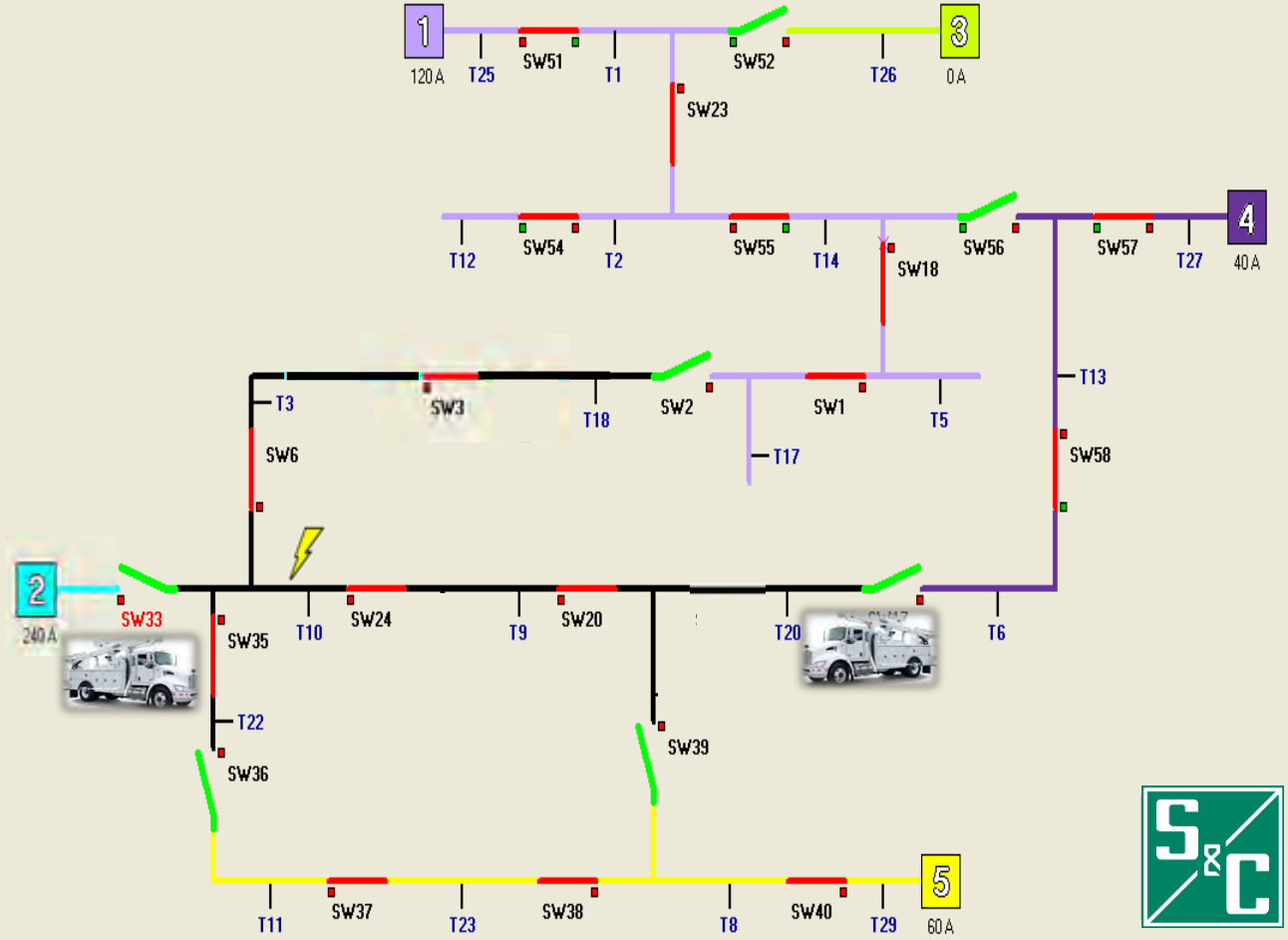




Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
18	2,000	35,429	17.7	$128,448

OLD GRID

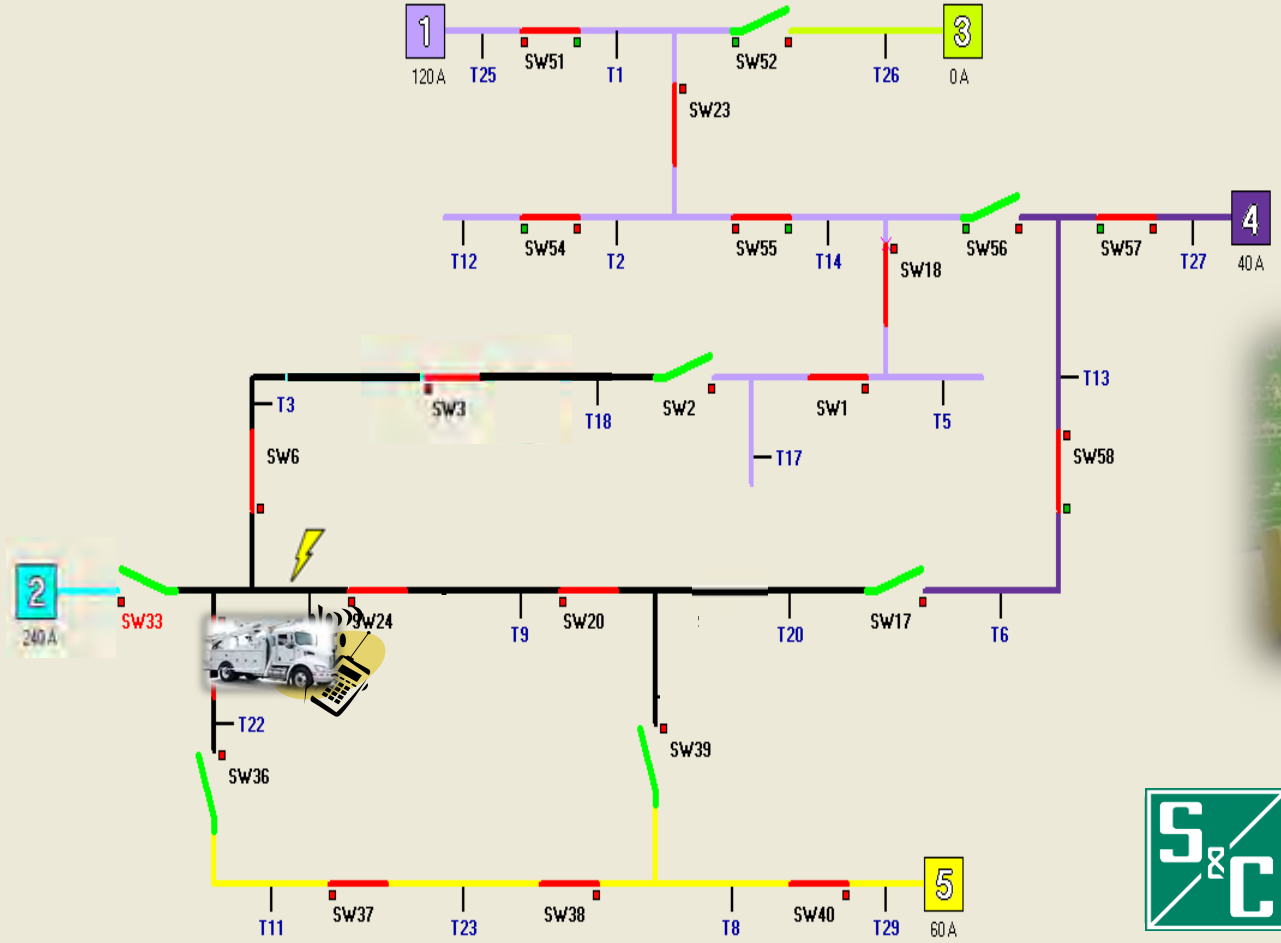
Crew locates fault after a 13 minute search.



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
31	2,000	62,000	31.0	$155,429

OLD GRID

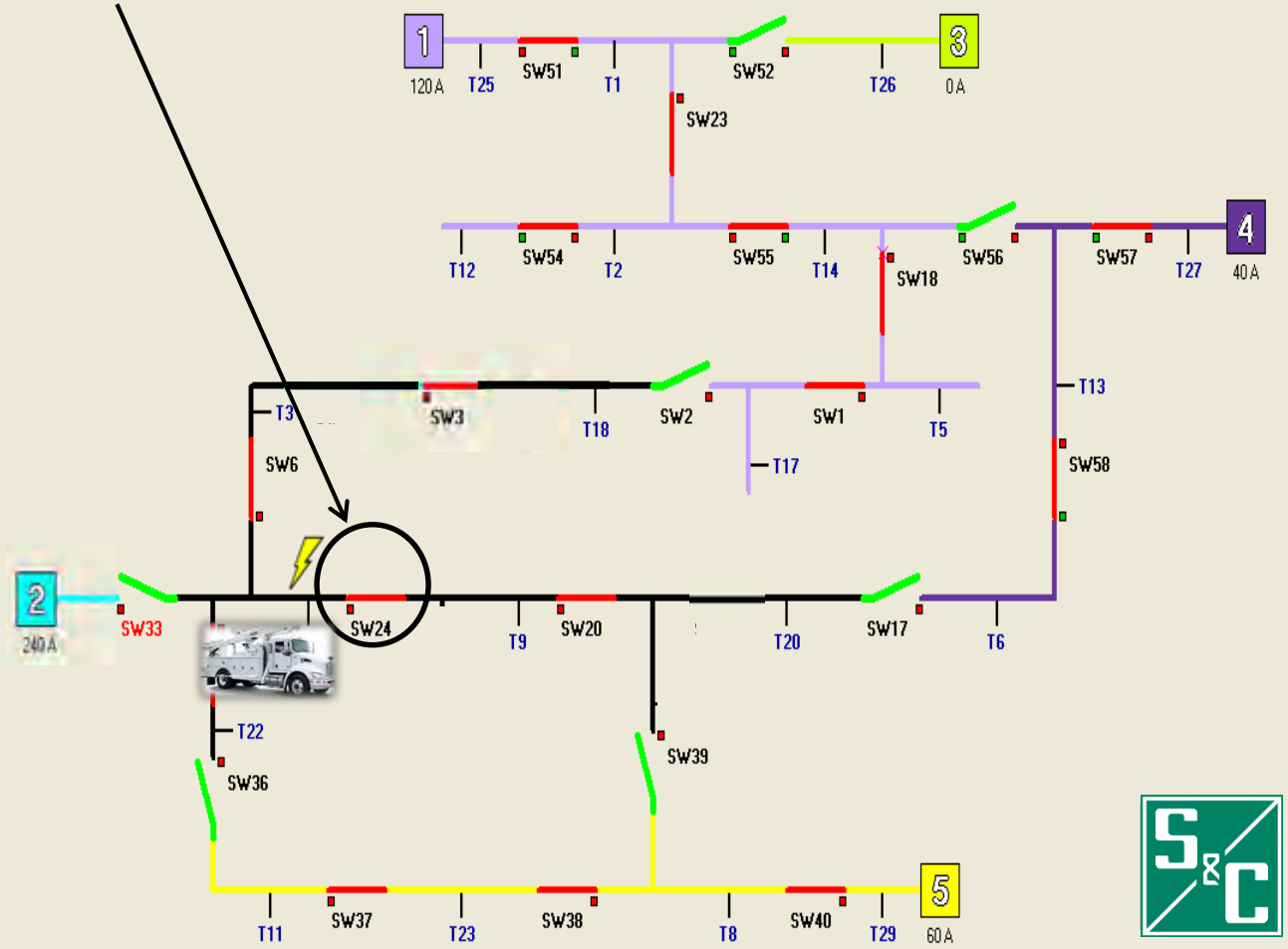
Control Center takes 4 minutes to develop switching orders ... and convey to crew.



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
35	2,000	70,857	35.4	$164,422

OLD GRID

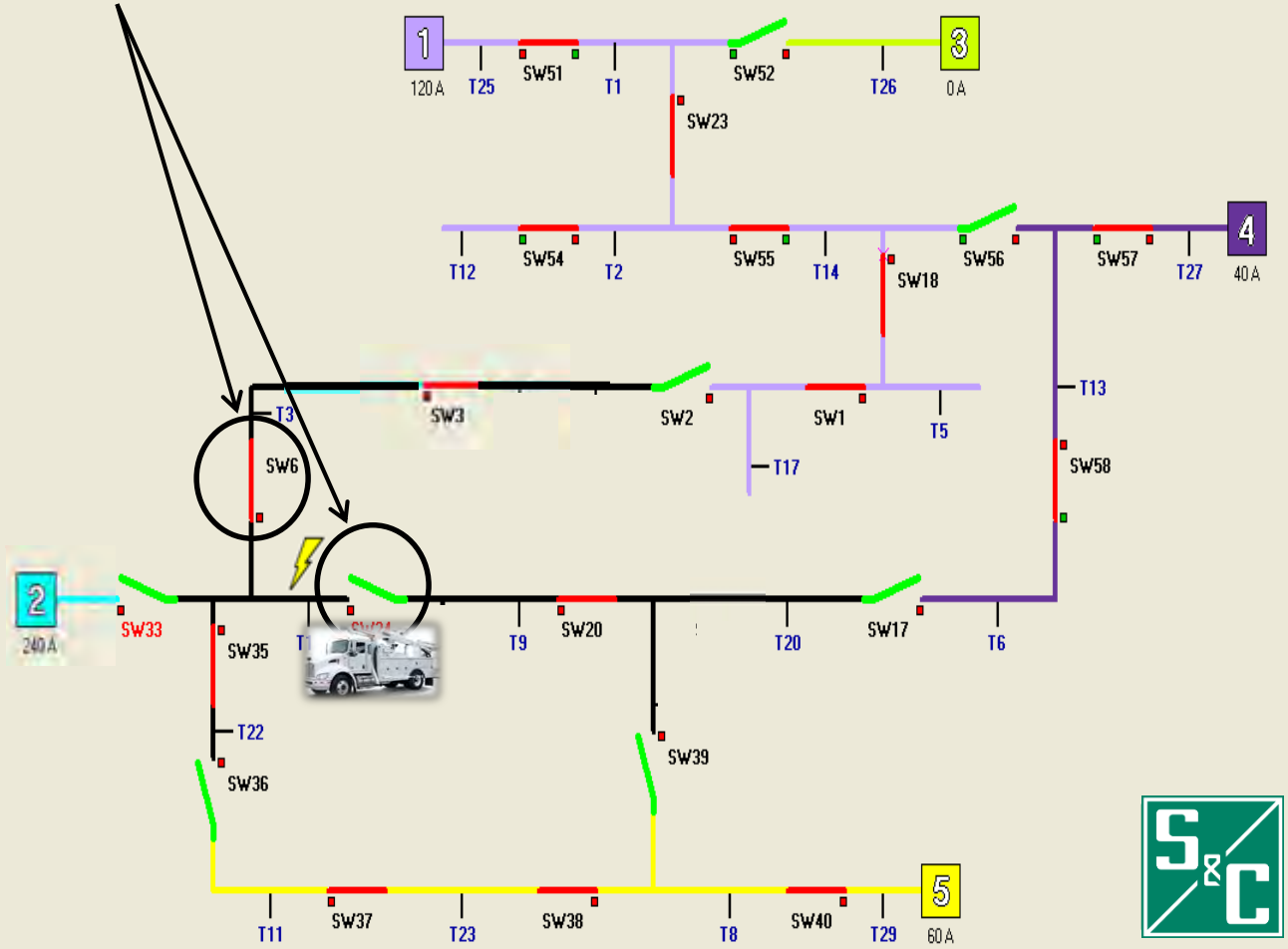
Crew drives to switch 24 to open



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
43	2,000	86,800	43.4	$180,610

OLD GRID

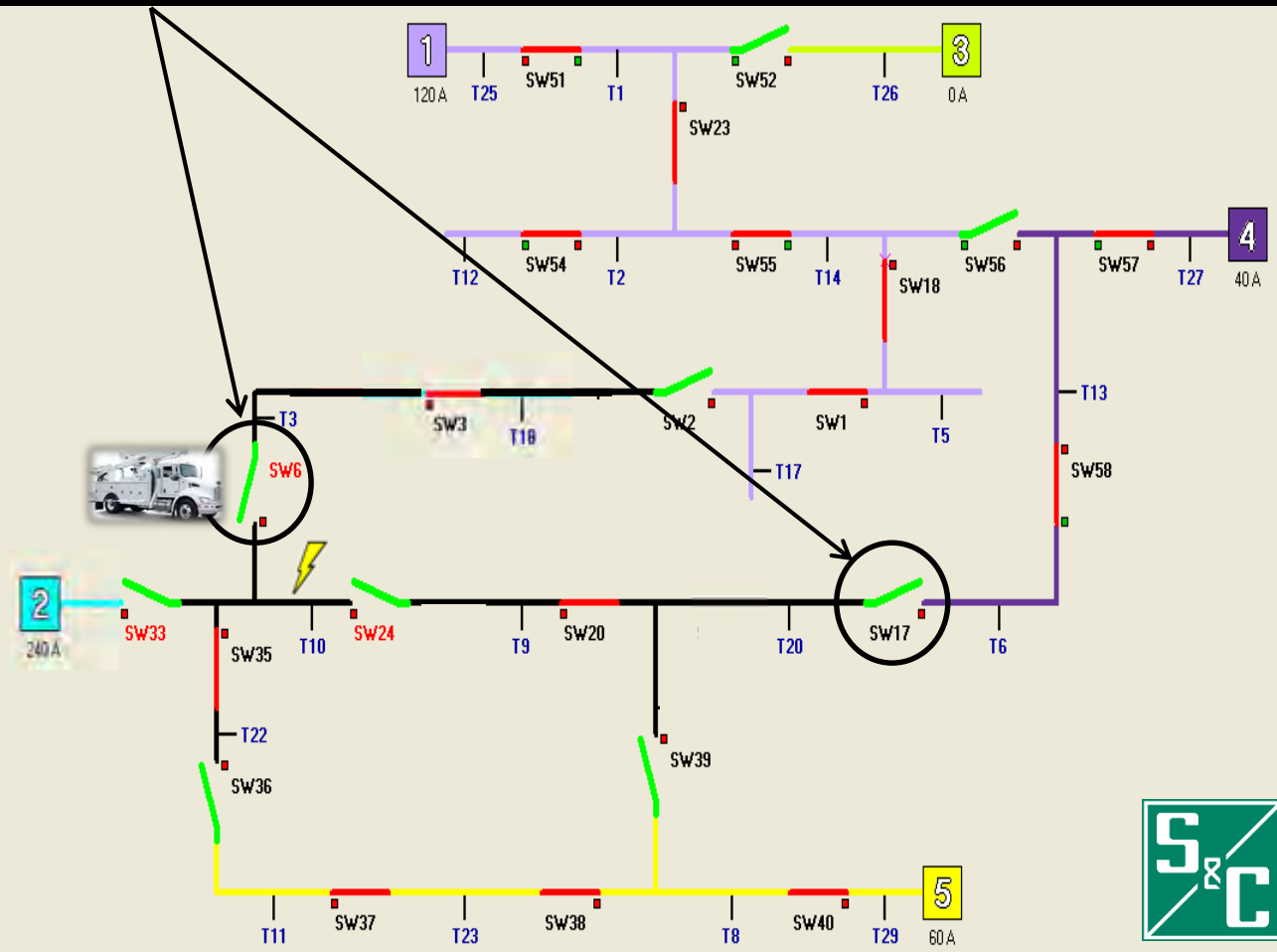
Crew drives to switch 6 to open



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
52	2,000	104,514	52.3	$198,597

OLD GRID

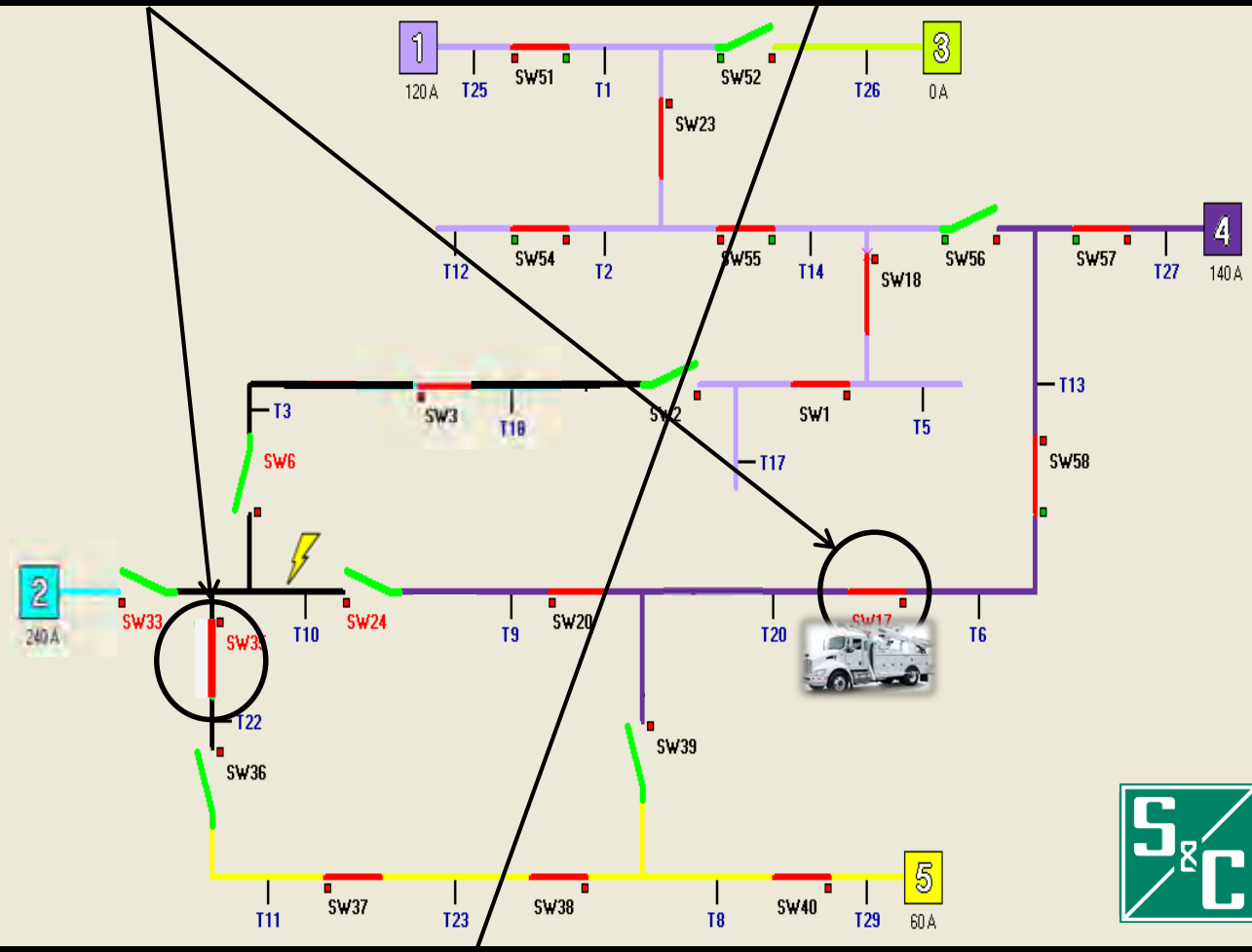
Crew drives to switch 17 to close



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
71	2,000	141,714	70.9	$236,370

OLD GRID

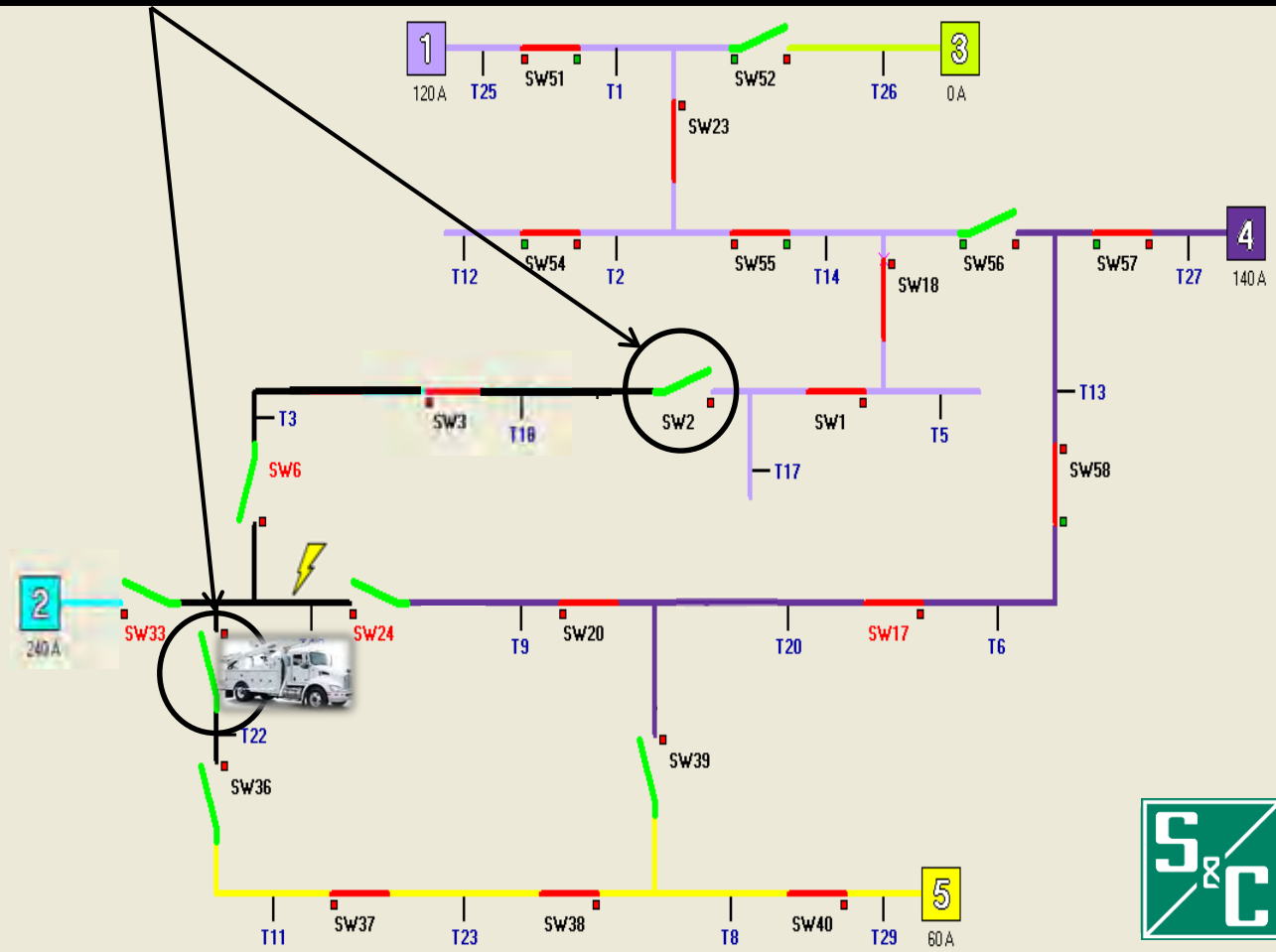
Crew drives to switch 35 to open



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
80	1,334	154,120	77.1	$248,966

OLD GRID

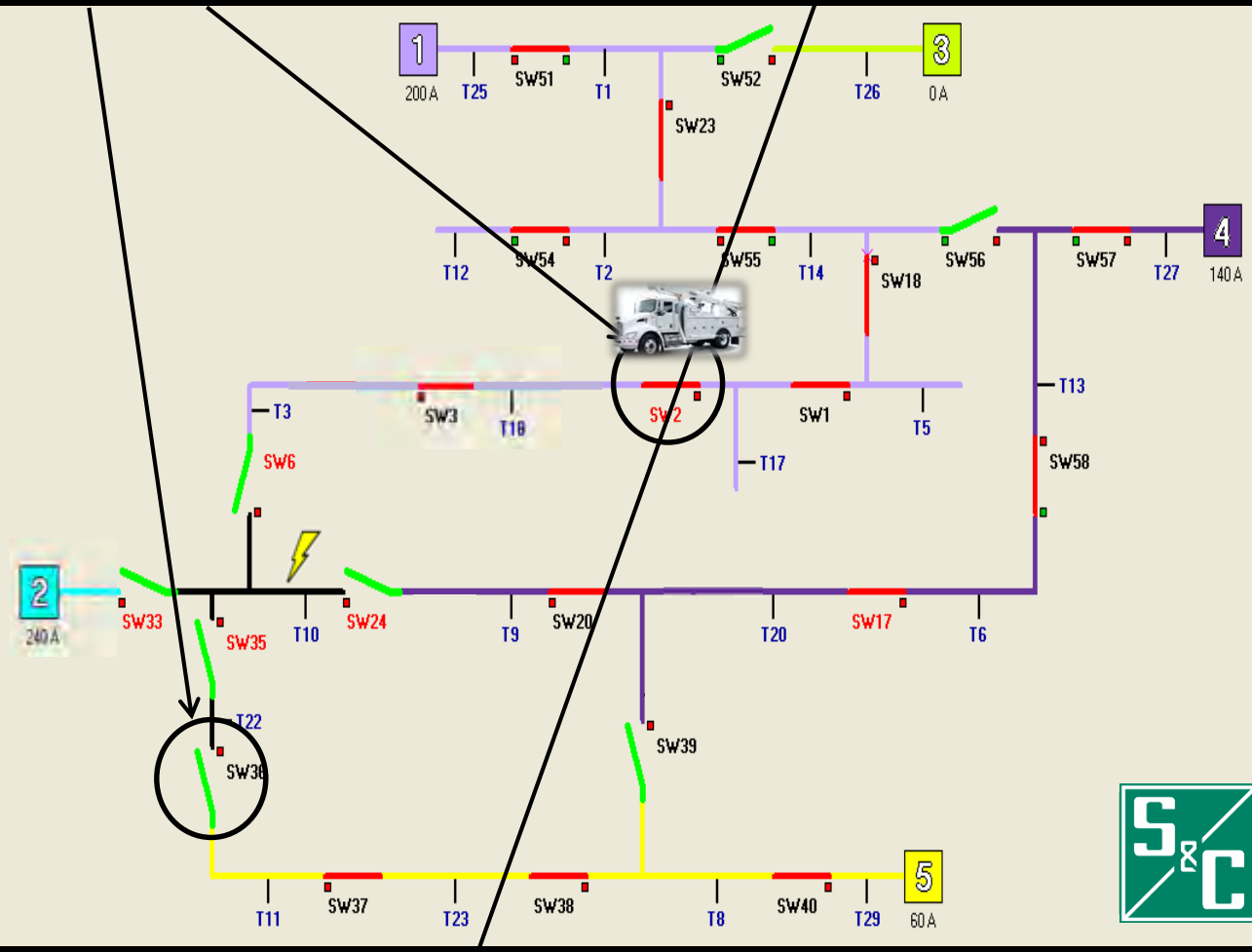
Crew drives to switch 2 to close



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
93	1,334	171,843	85.9	$266,962

OLD GRID

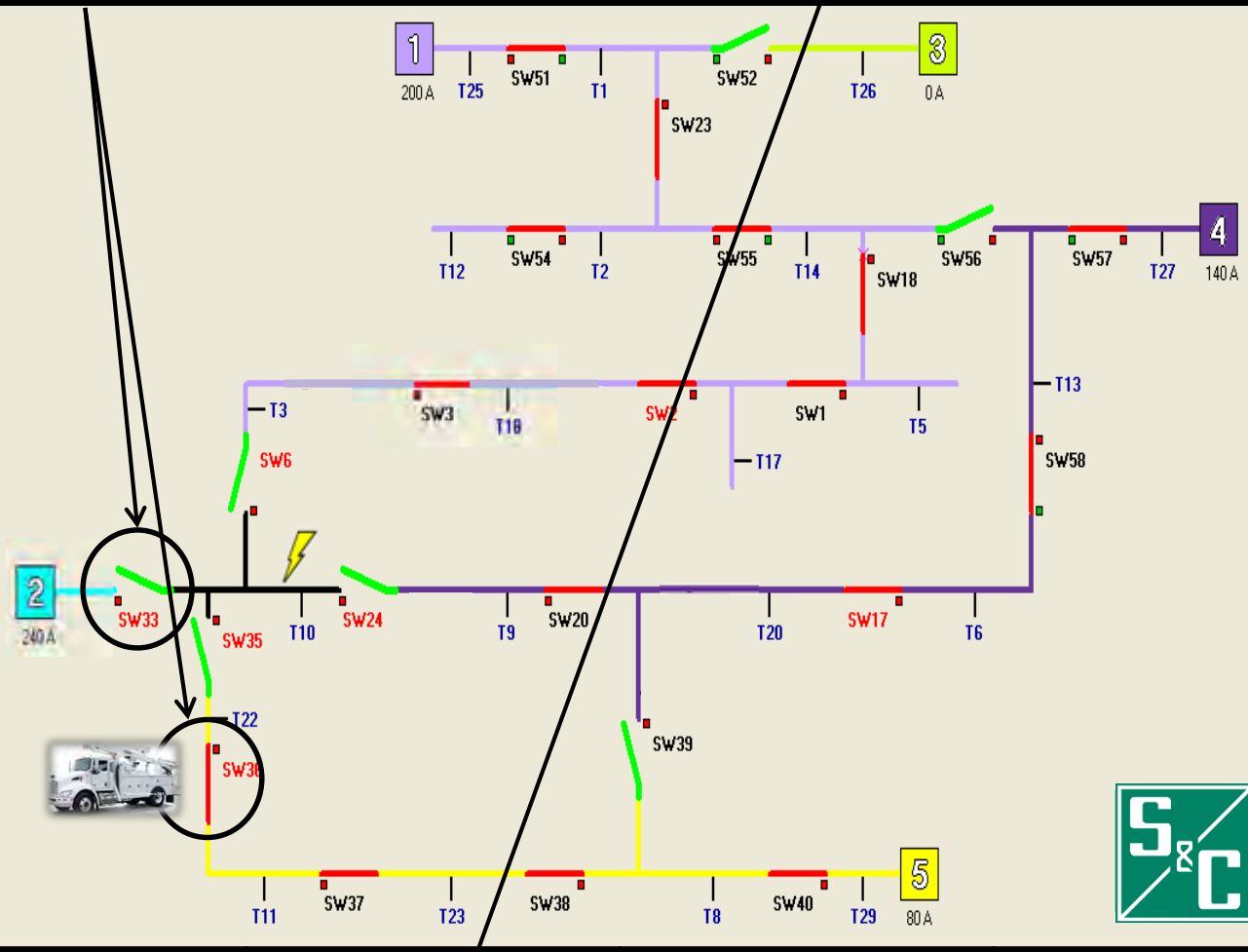
Crew drives to switch 36 to close



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
102	668	178,349	89.2	$273,569

OLD GRID

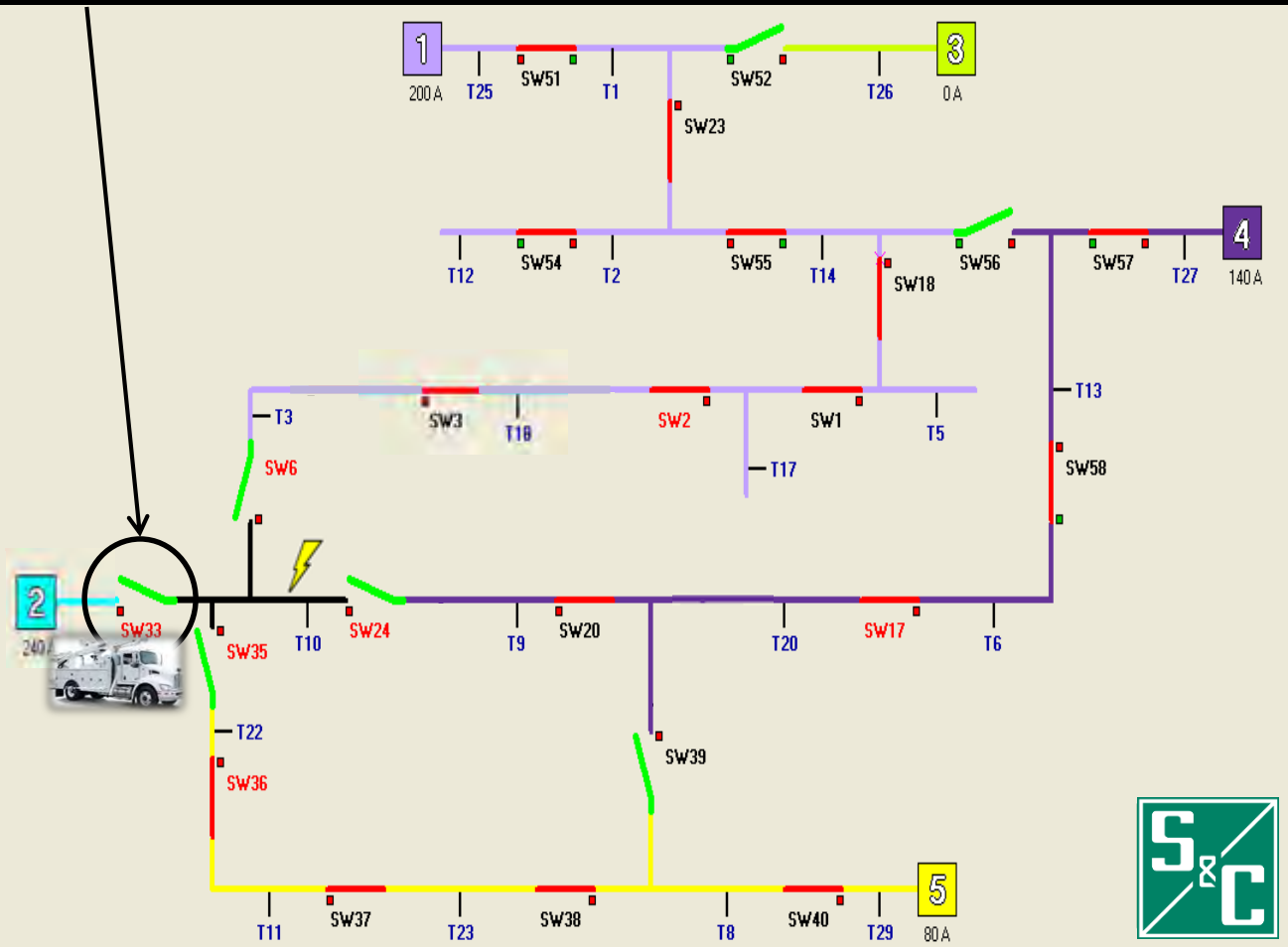
Crew drives to circuit breaker 33 to open visible safety switch



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
105	334	179,828	89.9	$275,071

OLD GRID

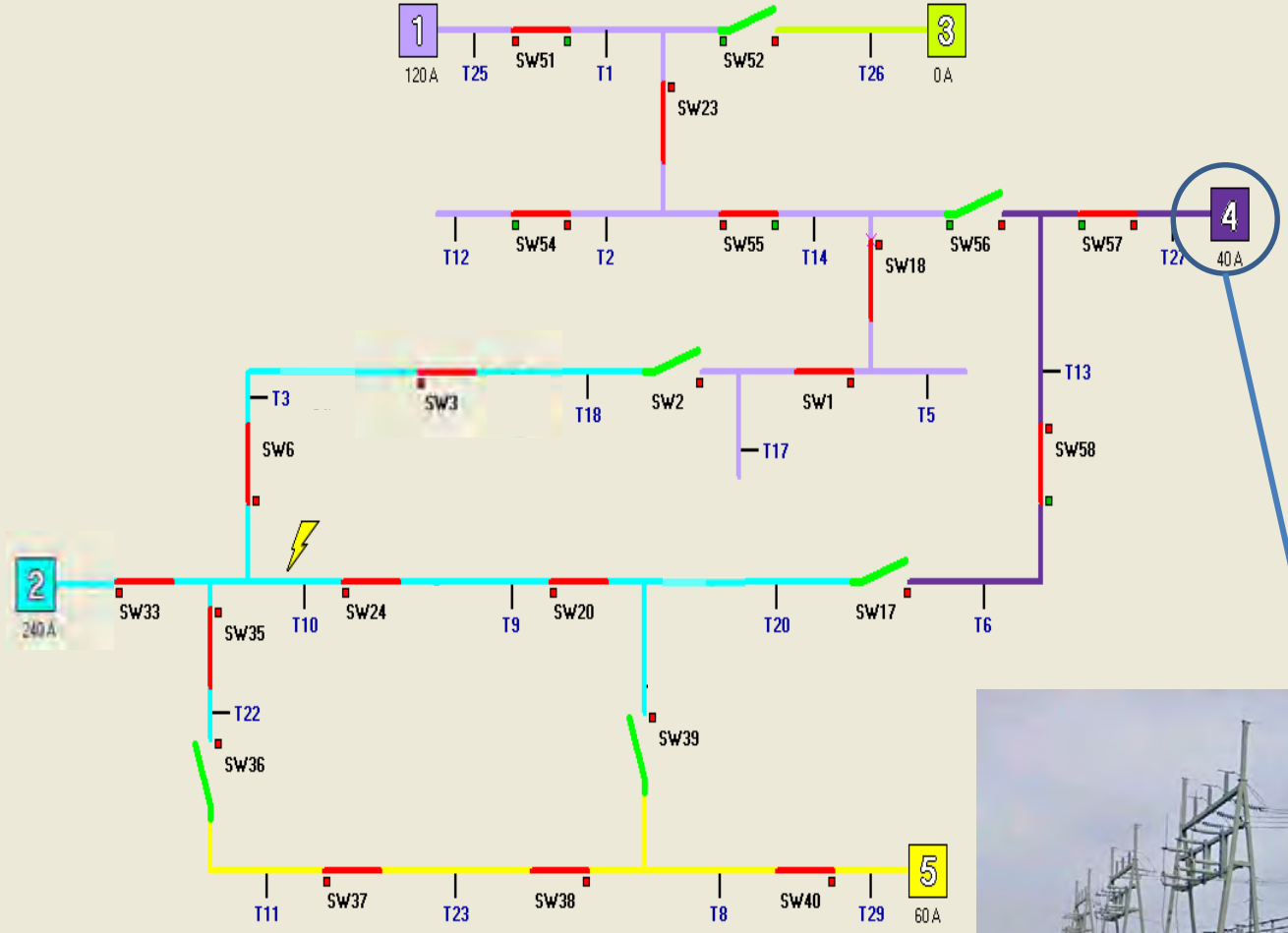
Crew drives to the fault to begin repairs



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
110	334	181,307	90.7	$276,573

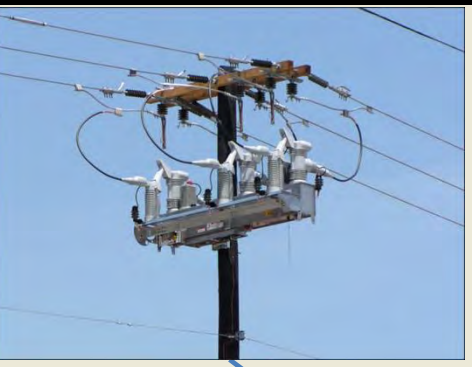
SMART GRID

How do things unfold in the Smart Grid World?



SMART GRID

How do things unfold in the Smart Grid World? Watch the circled switches to find out …



SMART GRID

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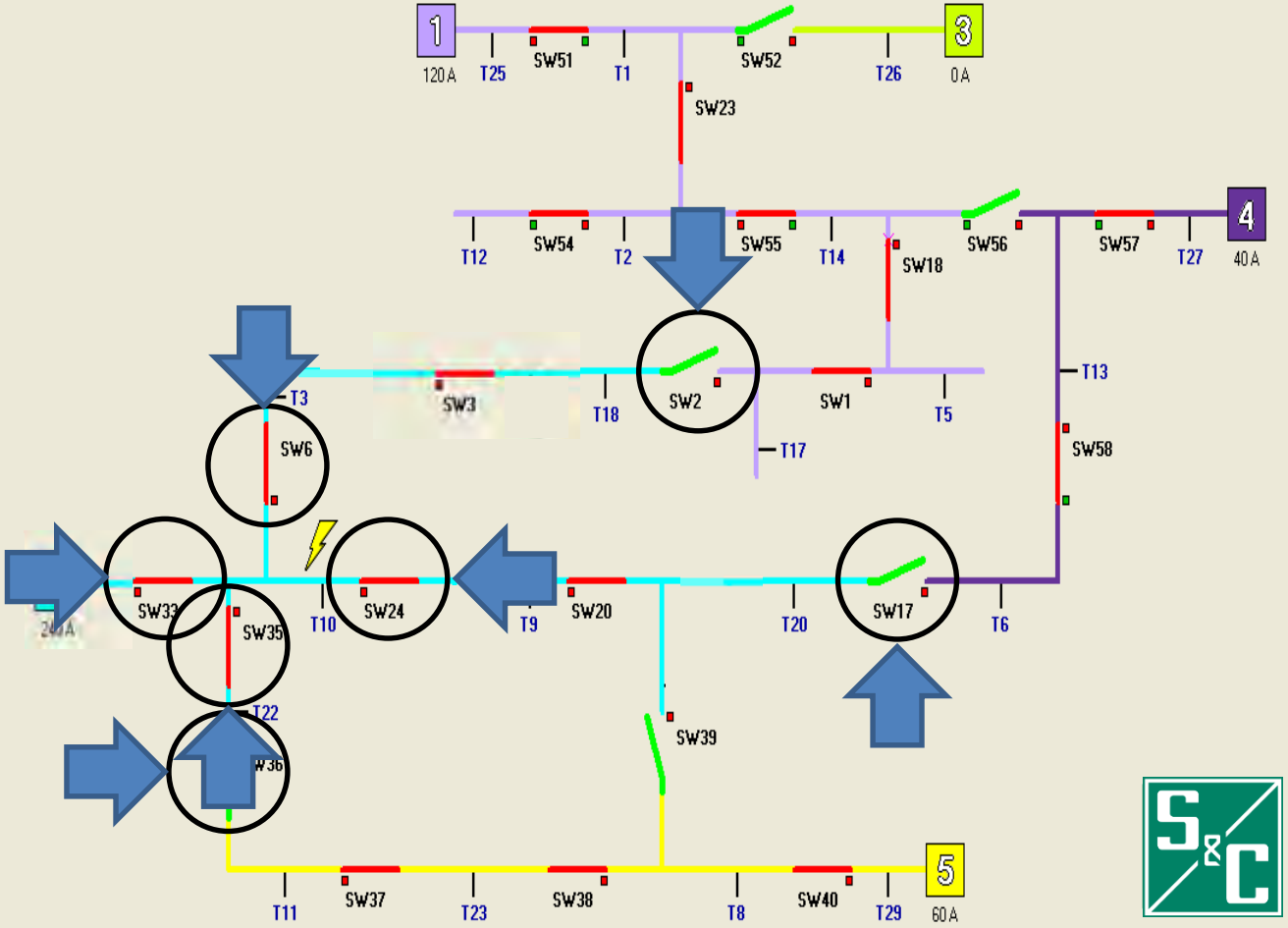
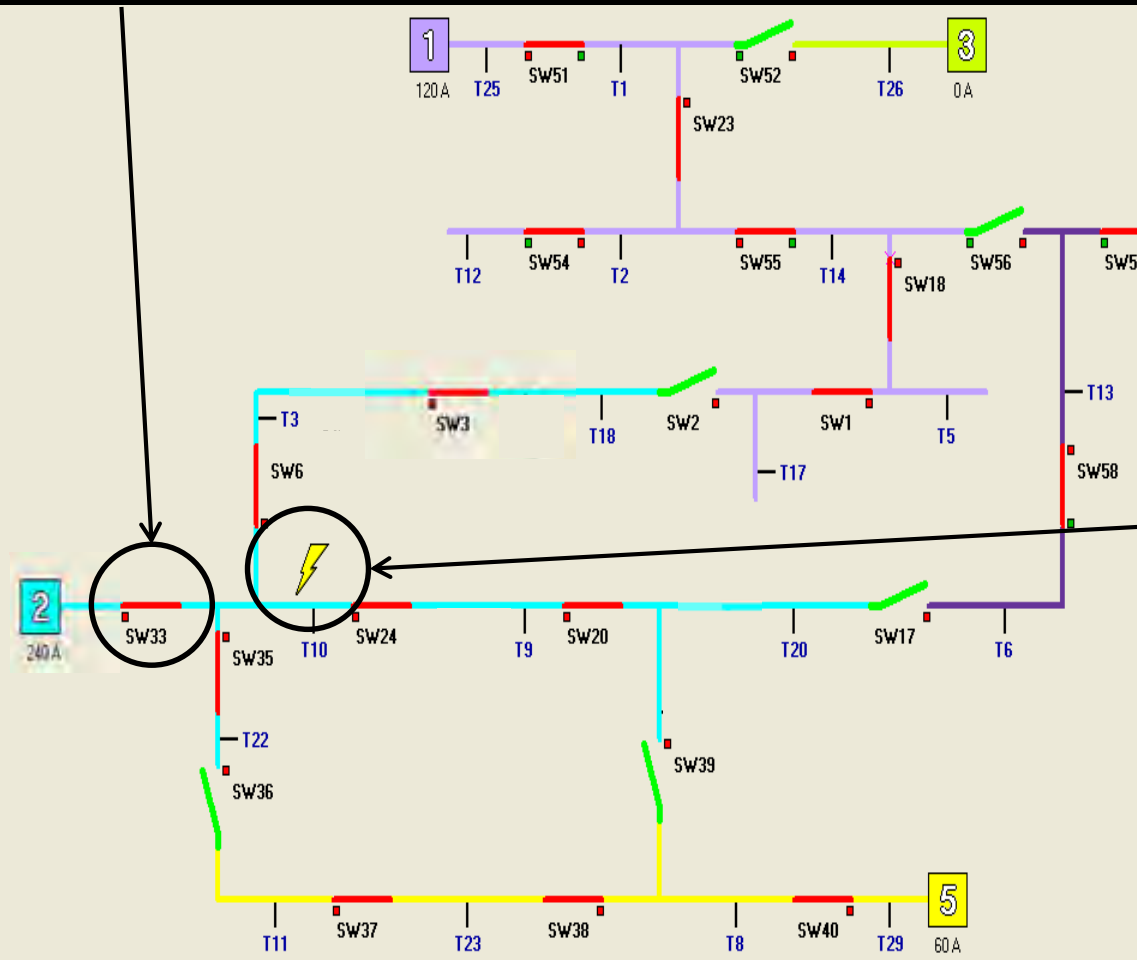


Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
0	0	0	0	$0

SMART GRID

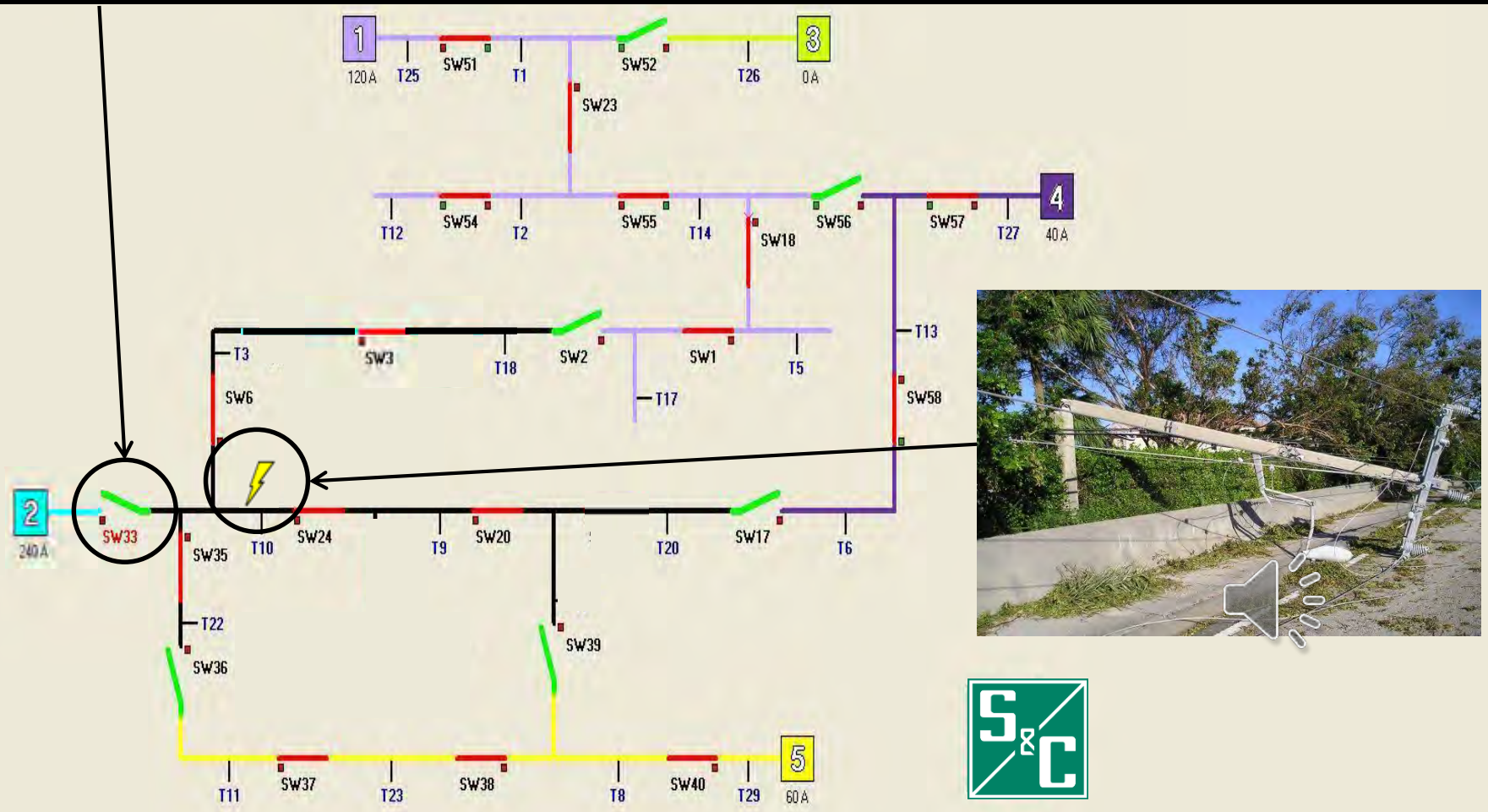
Circuit Breaker 33 – trips open



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
0	0	0	0	$0

SMART GRID

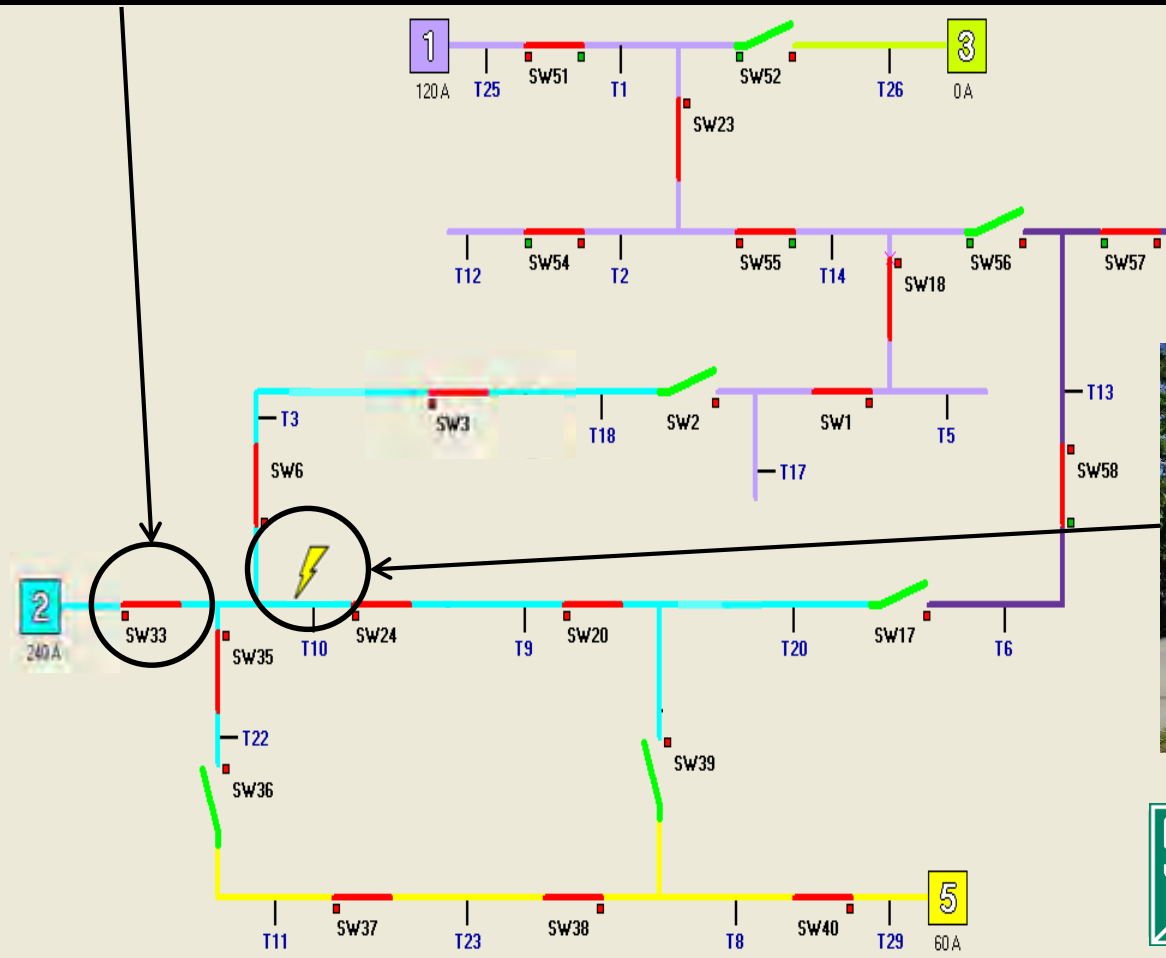
Circuit Breaker 33 – trips open



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
0	2,000	0	0	$92,474

SMART GRID

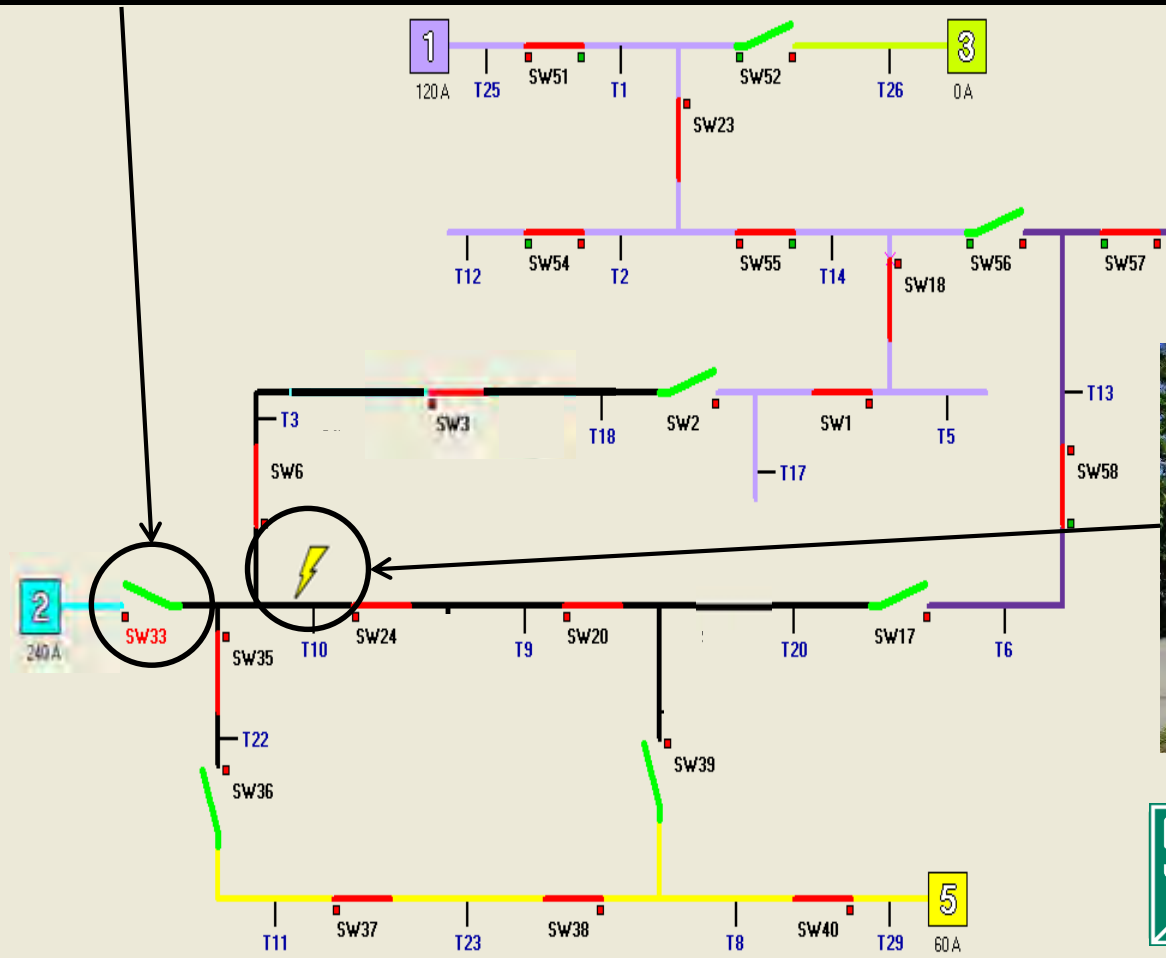
Circuit Breaker 33 – recloses anticipating a temporary fault (eg. animal contact).



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
0	0	0	0	$92,474

SMART GRID

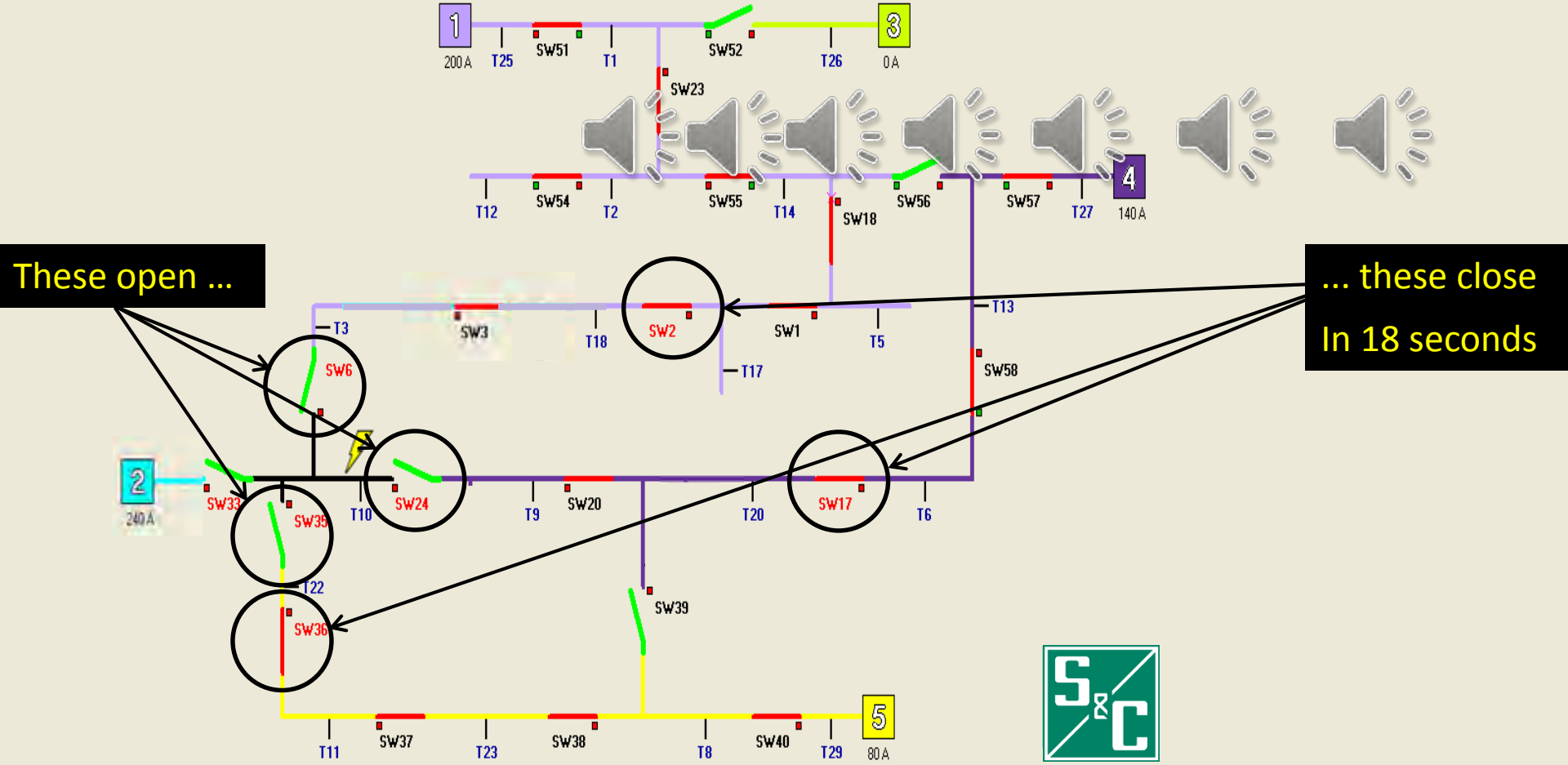
Circuit Breaker 33 – trips again and stays open (lock out)



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
0	2,000	0	0	$92,474

SMART GRID

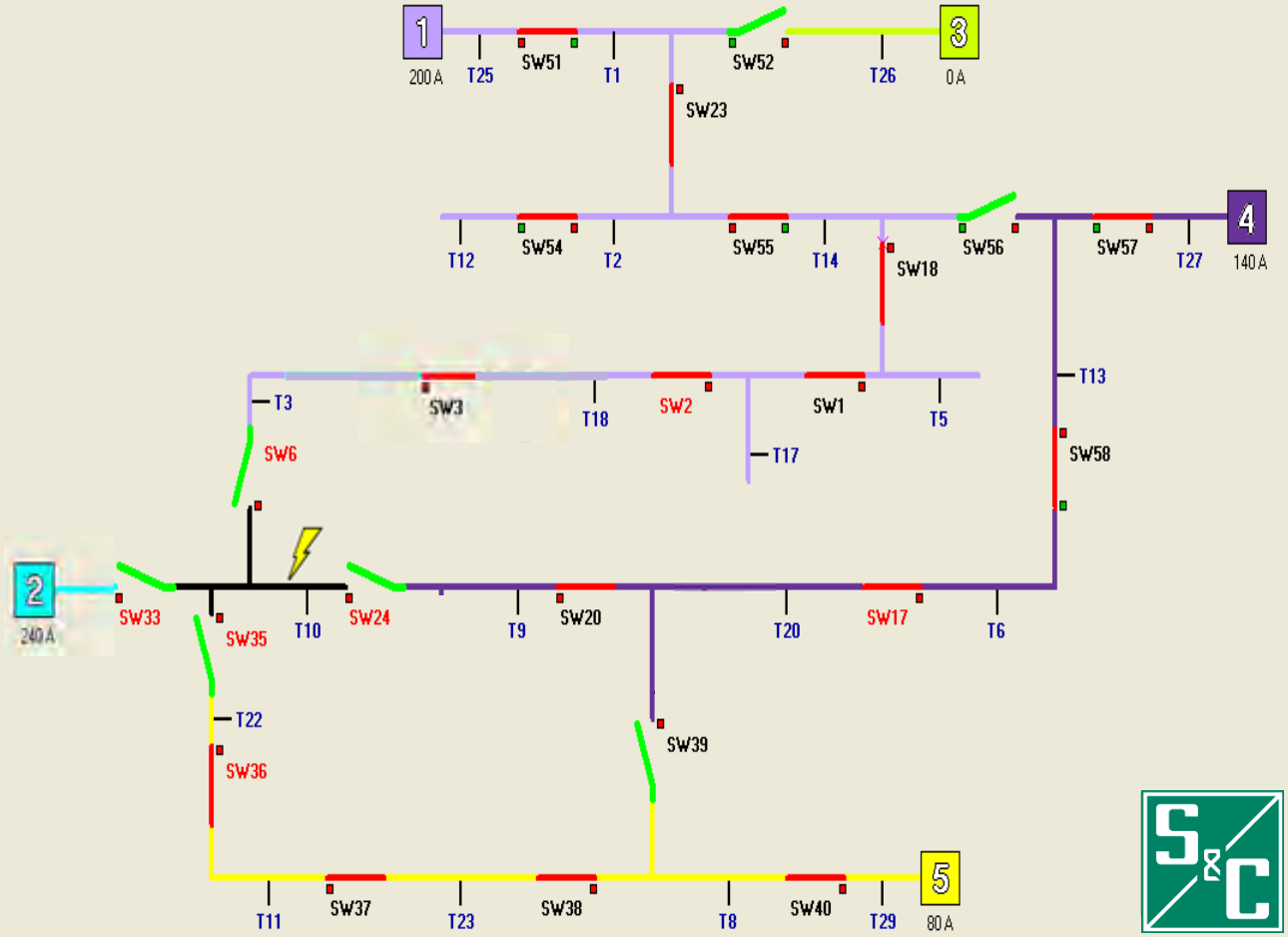
Smart Grid informs Control Center of lock out AND restoration.



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
4	334	1,183	0.59	$93,676

SMART GRID

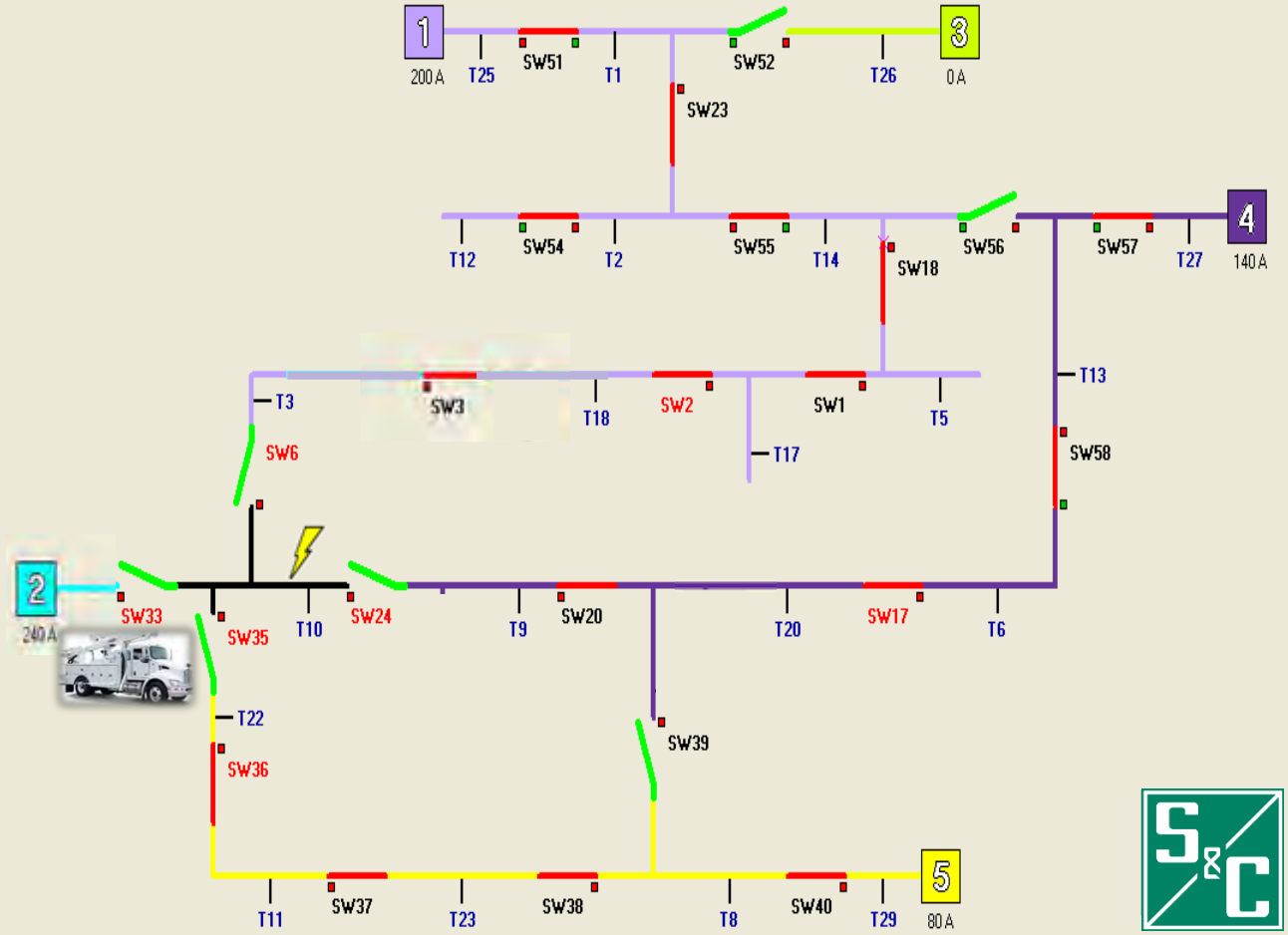
Traffic lights are operating – Gets there sooner



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
8	334	2,662	1.33	$95,178

SMART GRID

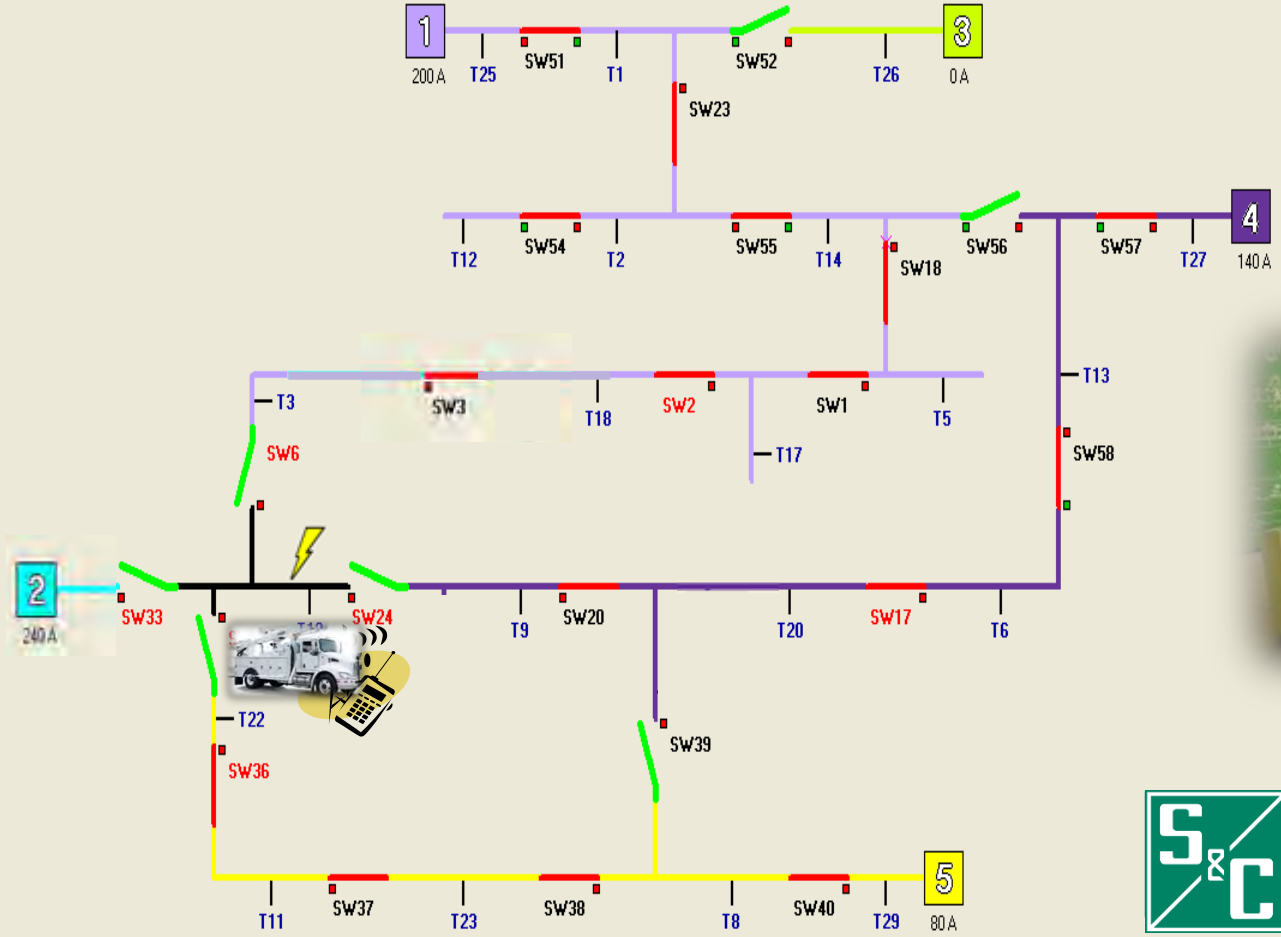
Crew locates fault after 9 minute search.



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
17	334	5,621	2.81	$98,182

SMART GRID

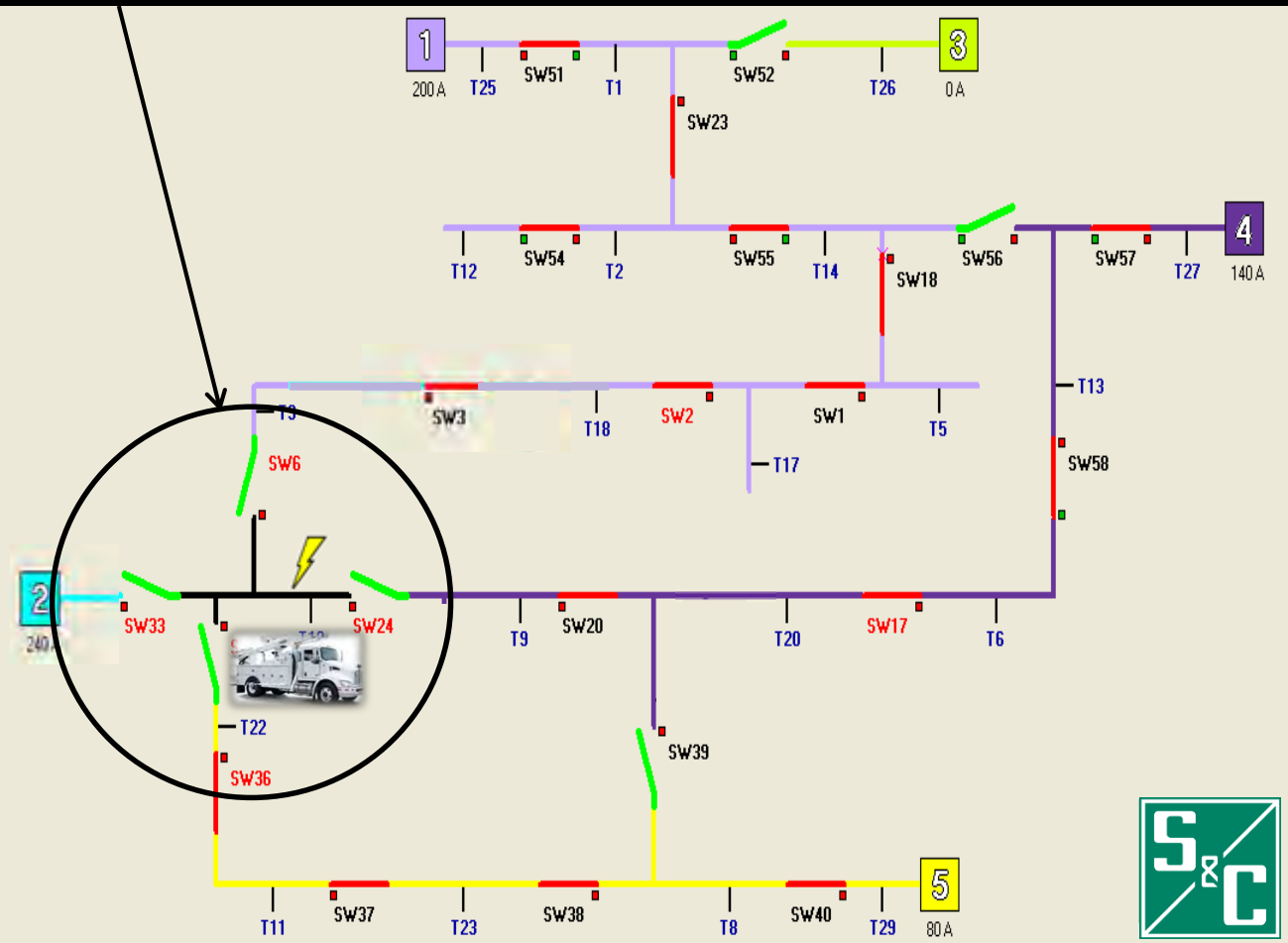
Control Center already knew area of fault – switching orders in 2 minutes.



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
19	334	6,508	3.25	$99,083

SMART GRID

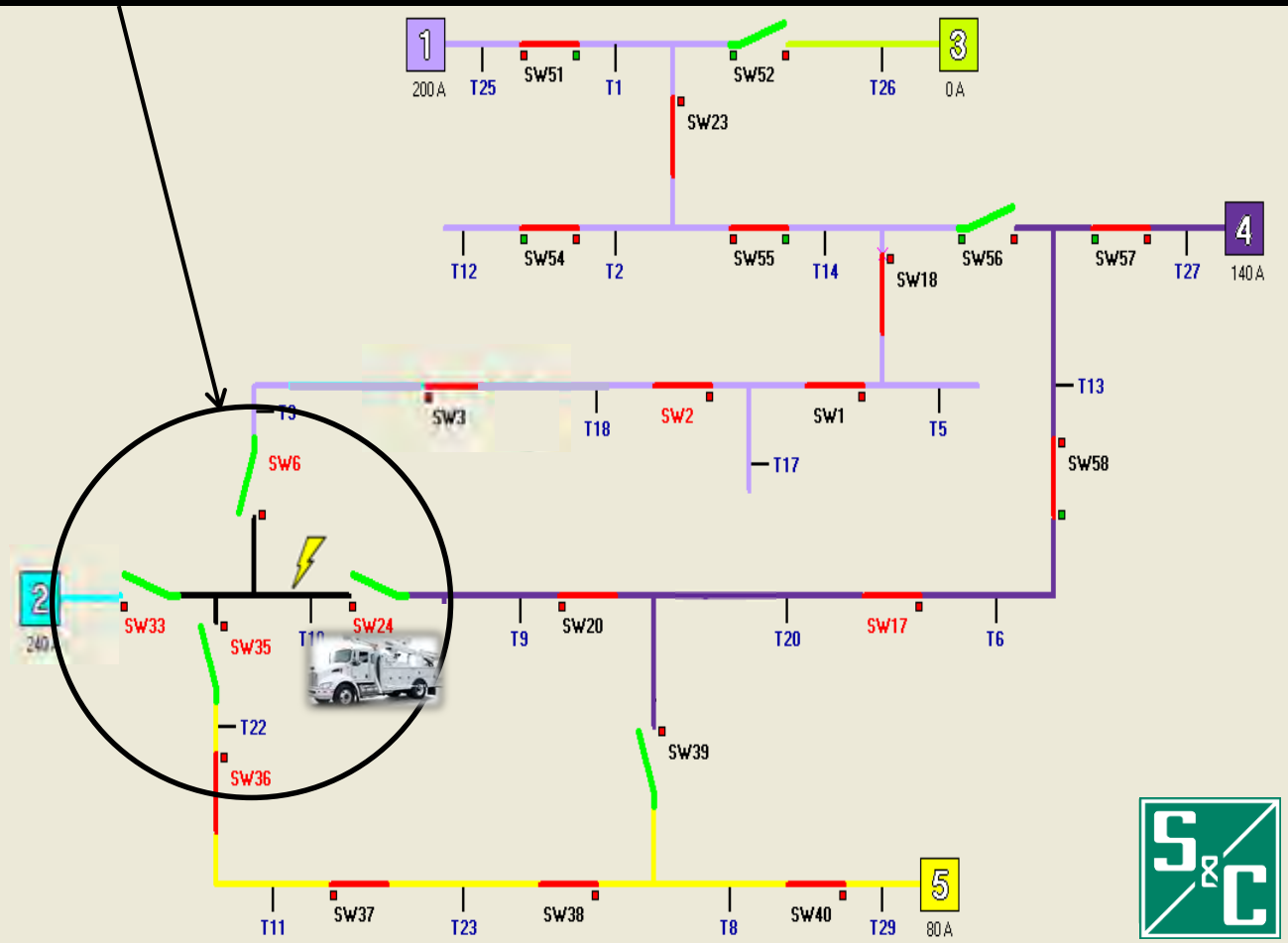
Crew drives to switches surrounding fault to open visible gap safety switches



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
27	334	8,875	4.44	$101,486

SMART GRID

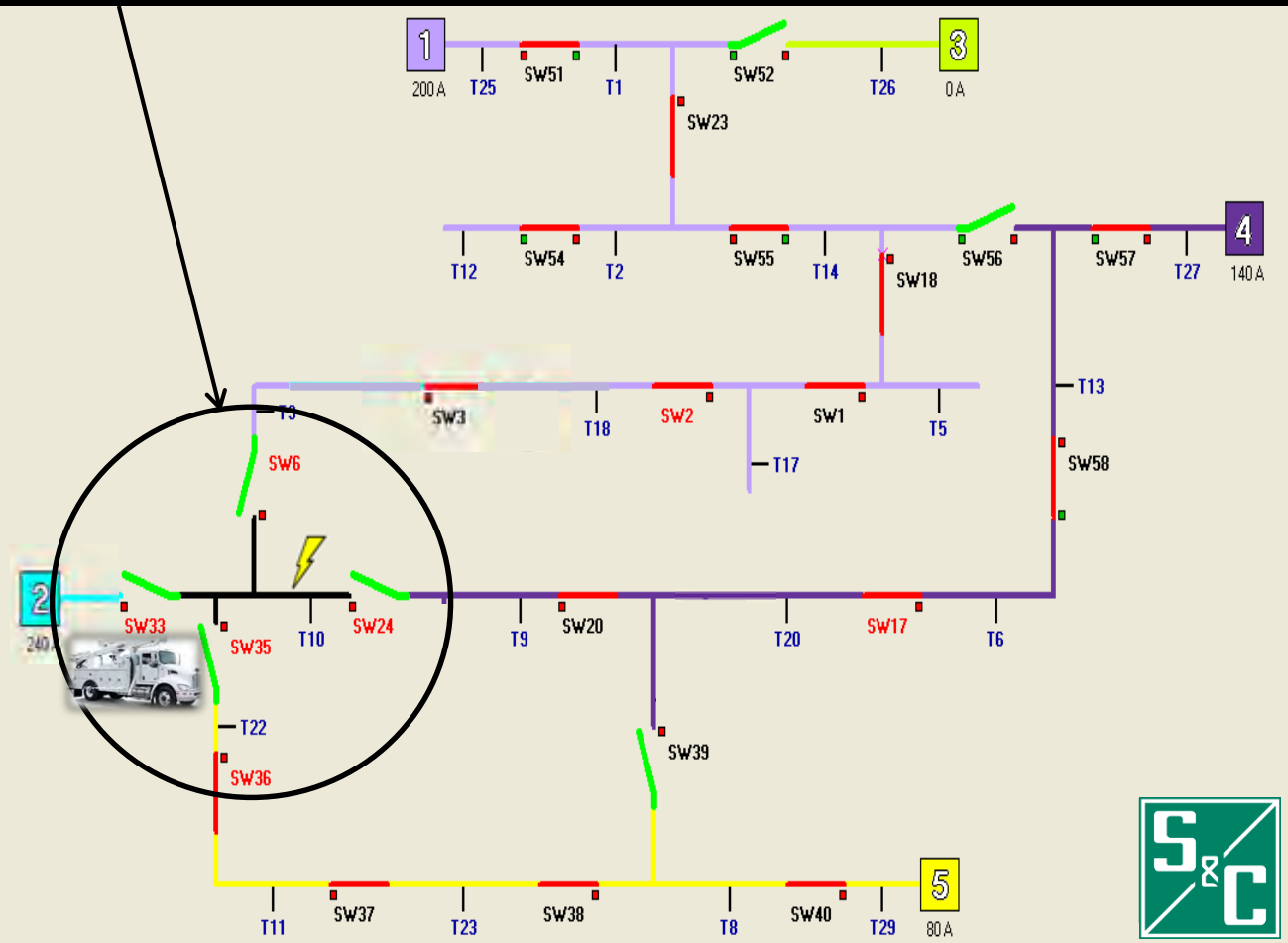
Crew drives to switches surrounding fault to open visible gap safety switches



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
35	334	11,833	5.92	$104,490

SMART GRID

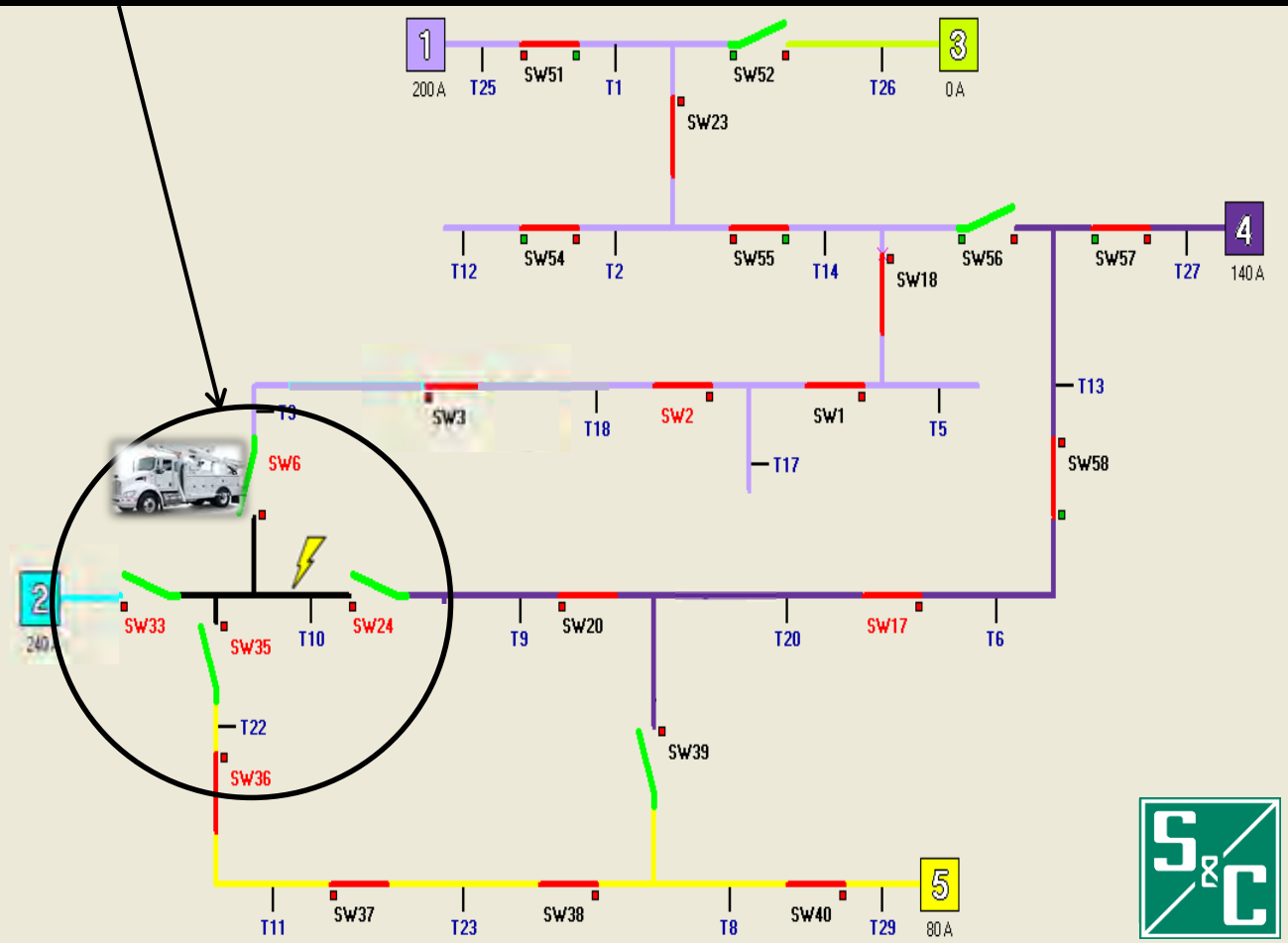
Crew drives to switches surrounding fault to open visible gap safety switches



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
44	334	14,791	7.40	$107,493

SMART GRID

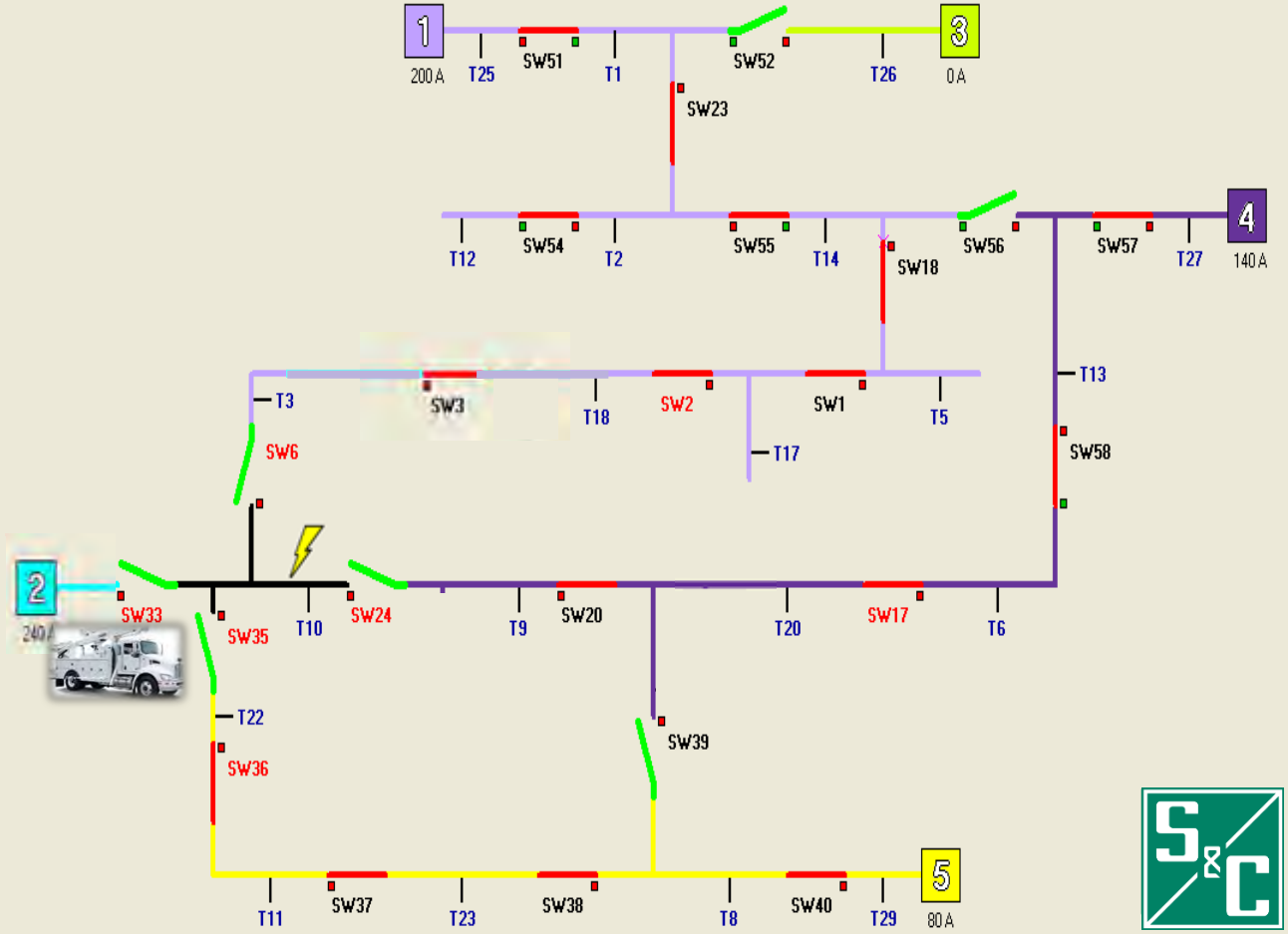
Crew drives to switches surrounding fault to open visible gap safety switches



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
53	334	17,750	8.87	$110,497

SMART GRID

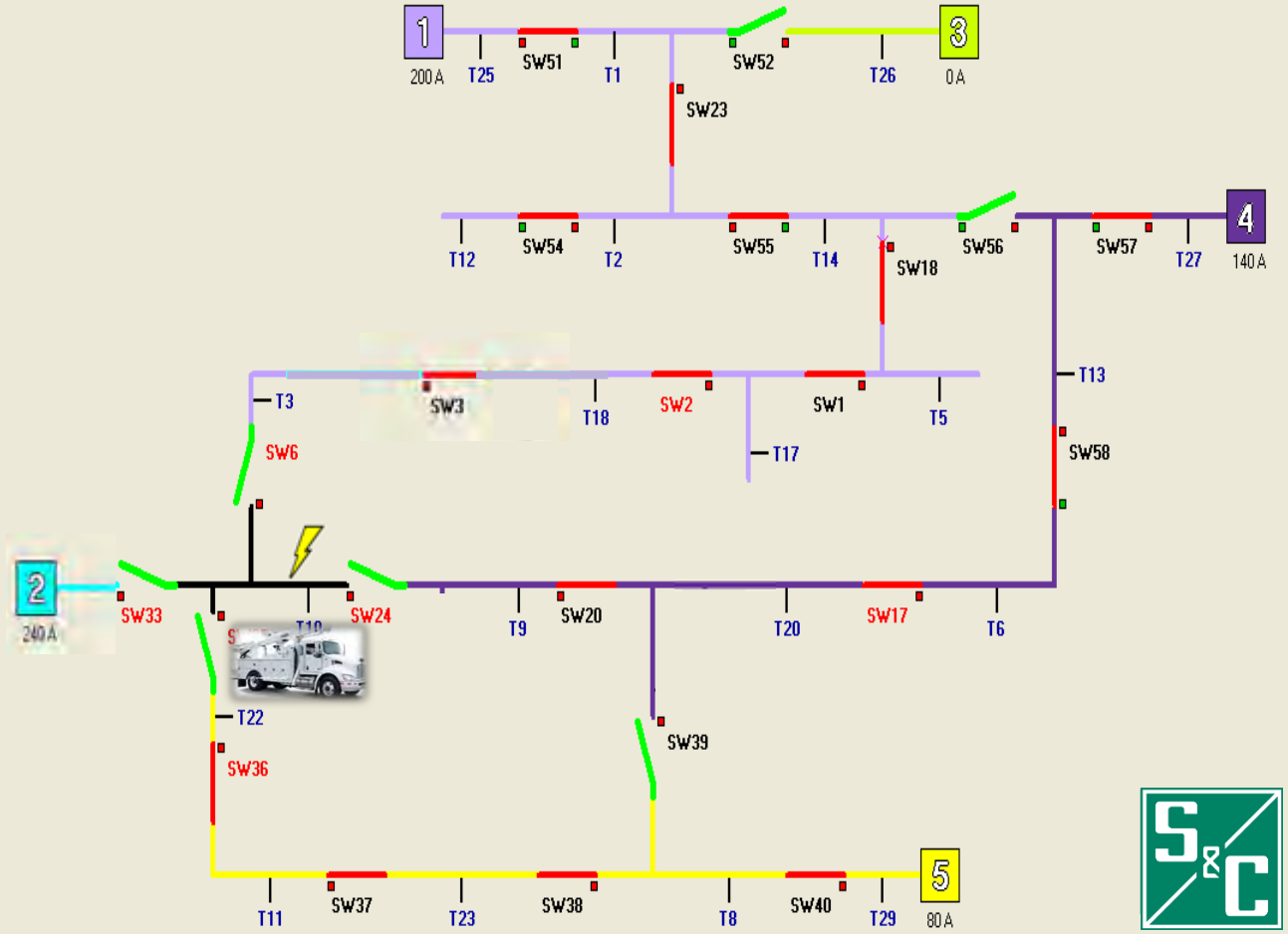
Crew drives to the fault …



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
57	334	18,933	9.47	$111,699

SMART GRID

Crew drives to the fault … and can begin repairs … 52 MINUTES earlier!



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
58	334	19,229	9.61	$111,999

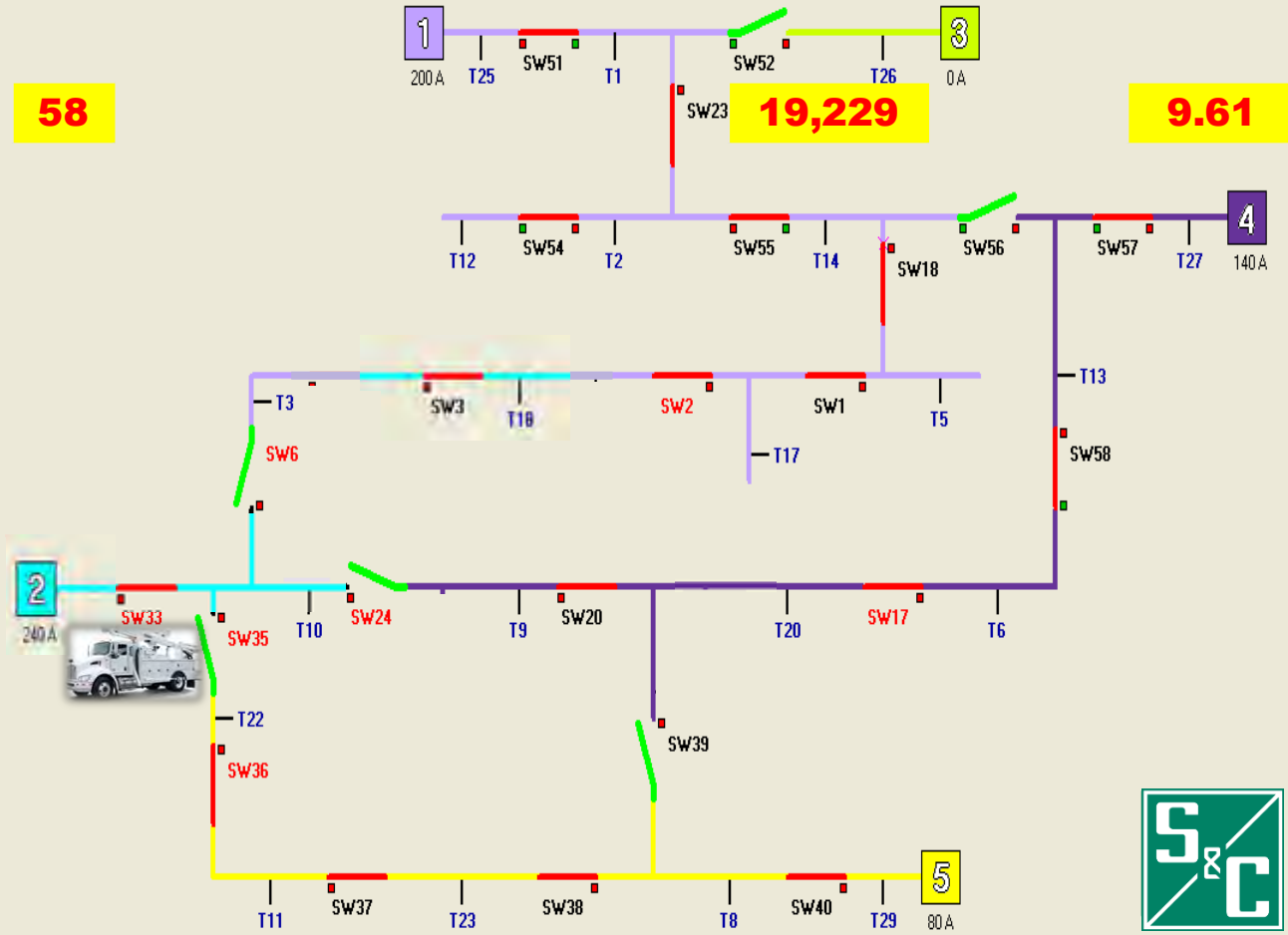
Team Configuration --> C:\Documents and Settings\User\Desktop\IntelliTEAM Instant Replay Anywhere ICC\IntelliTEAM Instant Replay Anywhere ICC\Files\InstantReplays\Flt F10 SG.SwLog

File Edit View Tools Help

13 of 21 Steps | Play | 1X | Config File: SG29a moved NO from 137 to 136.Netlist

OLD GRID

110	334	181,307	90.7	$276,573
58		19,229	9.61	$111,999



Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
	334			

Elapsed Time (Minutes)	# of Customers without Power	Customer Minutes of Interruption	SAIDI (minutes) (CMI/2000)	Customer Costs (Source:LBNL/DOE)
		OLD GRID		
110	334	181,307	90.7	$276,573
		SMART GRID		
58	334	19,229	9.61	$111,999

The Smart Grid reduced outage t 334 customers n just 18 secon ds
The Old Grid took 103 minutes

Customer Interruption Savings this event = 276,573 - 111,999 = 164,574
Since SAIFI = 1.29, actual Annualized Savings = 212,300

Annualized Cost for this Smart Grid Feeder = 62,500

- **If applied to *all* feeders, would mean rate increase of only about 1.3%**
- **If applied to 40% most critical/poor-performing feeders, rate increase would be only .5%**
- **And, this doesn't reflect utility operational savings that can reduce rates:**
  - **Fewer truck rolls, reduced overtime, fewer mutual assistance crews**

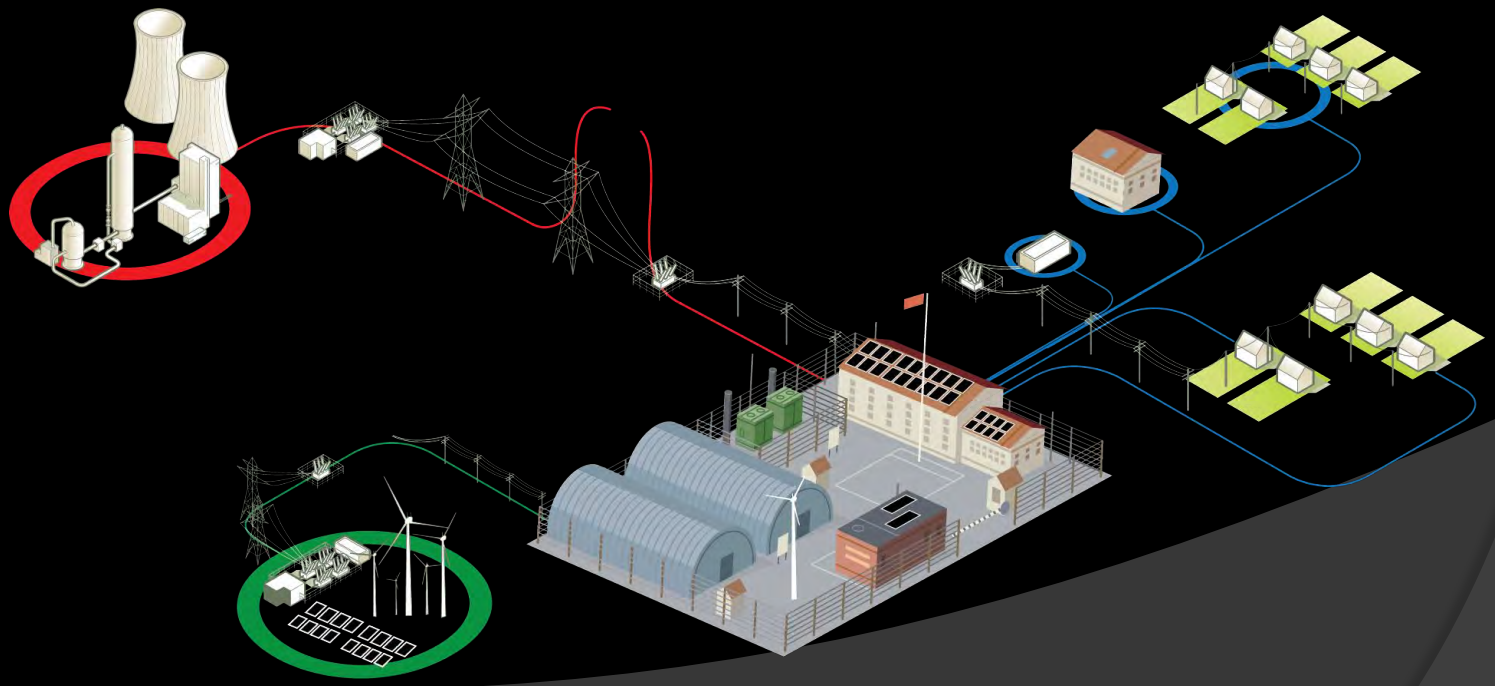
A CLEAR BUSINESS CASE TO IMPLEMENT SMART GRID SELF-HEALING

Self-healing Systems and Energy Storage: Keys to a Successful Microgrid

What is a Microgrid?

Per U.S. Department of Energy, a *microgrid* is:

"A localized grouping of distributed electricity sources, loads, and storage mechanisms which can operate both as part of the central grid or independently as an island."



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- Improve security
  - Self contained system easier to protect from outside attack
- **Local control and demand reduction**
  - Maintain critical systems and reduce overall demand

What's Needed to Implement a Microgrid?

- **Alternate energy sources**
- **Renewable energy**
  - Wind
  - Solar
  - Biomass
  - Geothermal
- **Non-renewable**

  Diesel Generators

  Natural Gas Generators
- **Combined Heat and Power**

Wind farms

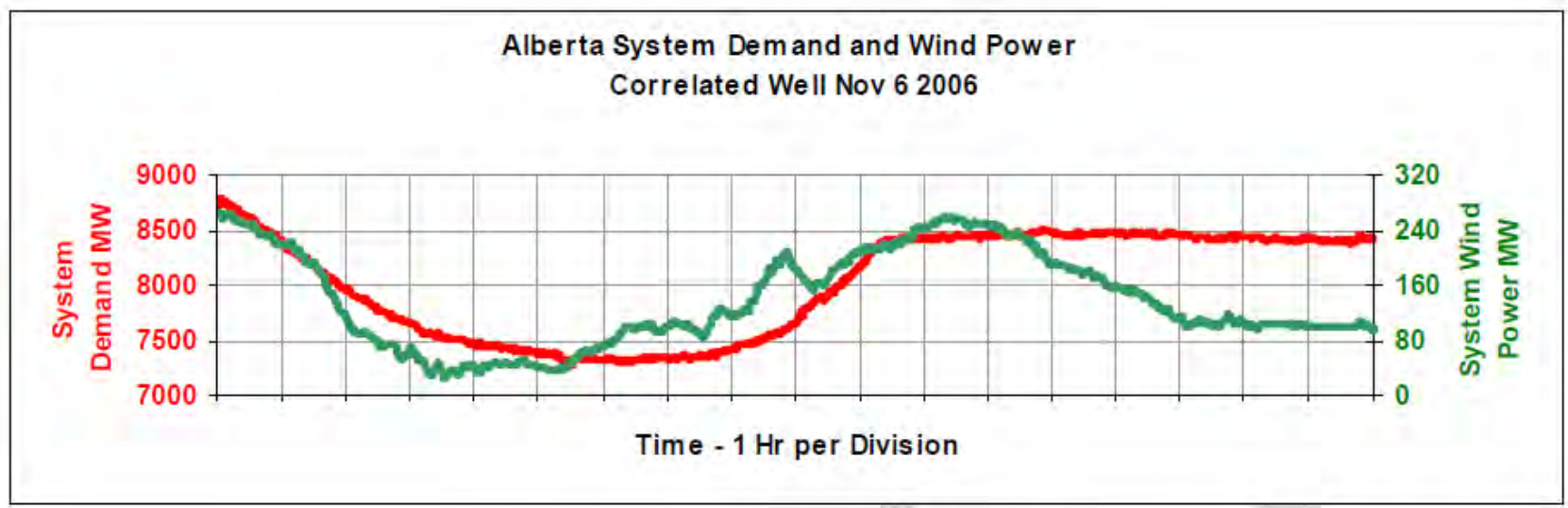
Solar

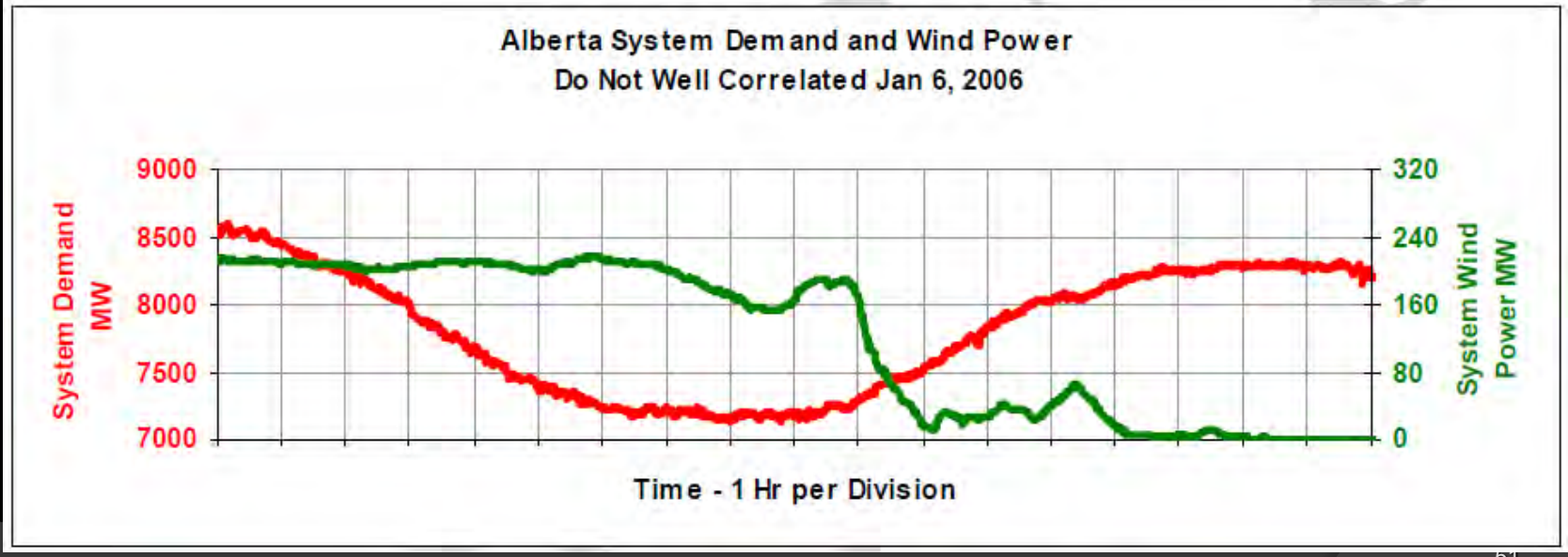
Generators

What's Needed to Implement a Microgrid?

- Alternate energy sources
- **Energy storage**
  - Smooth renewable output
  - Frequency and VAR support

Renewable power is not always there when you want it

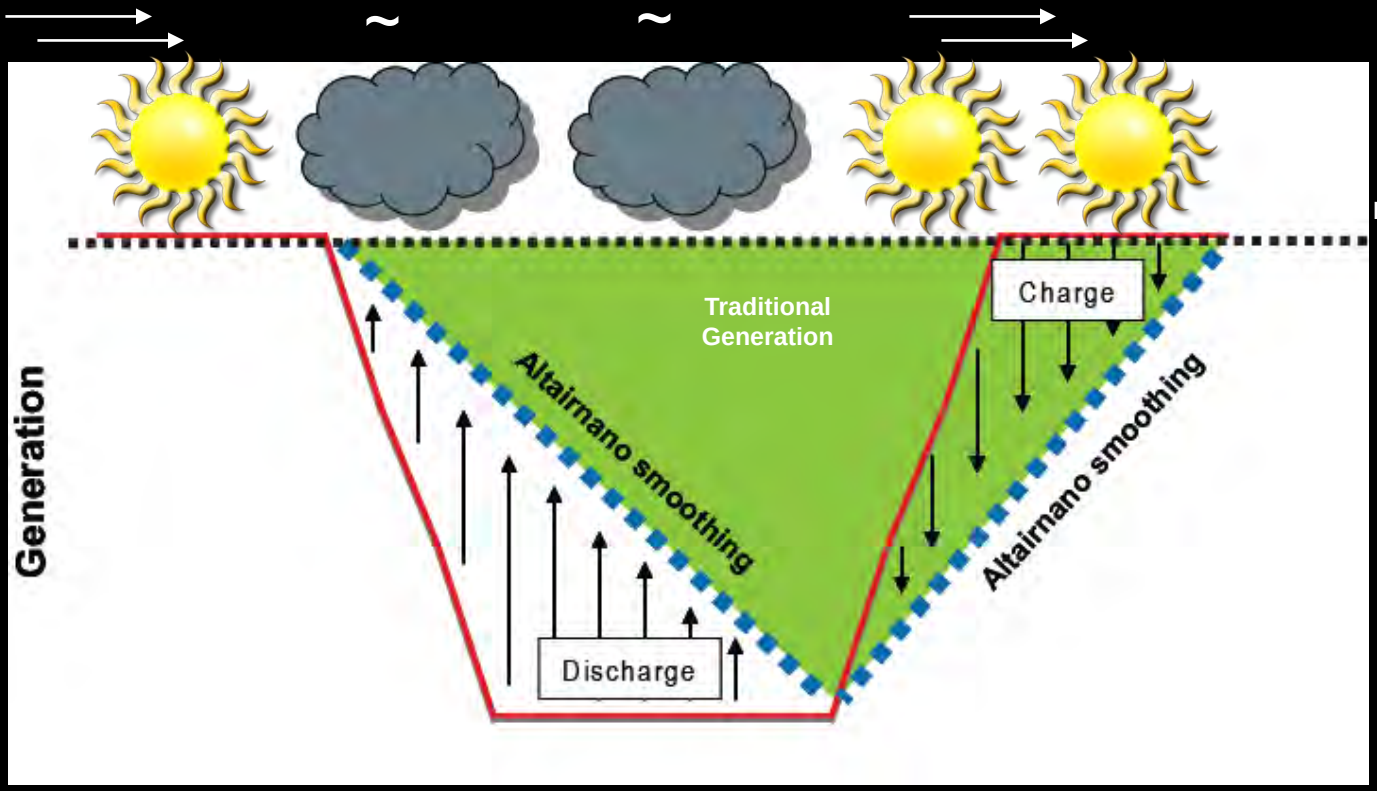




Renewable Energy Integration with Storage

Smoothing of Solar or Wind energy

Load shifting



Energy Storage can smooth the abrupt changes of renewable generation to the acceptable limit the grid can handle.

Short time energy storage
Frequency supply and support

Substation scale Energy Storage

S&C PureWave® Storage Management System

Multiple MegaWatt

Hours of support

Black start

Frequency support

Smooth wind output

www.xcelenergy.com/SiteCollectionDocuments/docs/W2BMilestone5Report_Public.pdf

Distributed Energy Storage

S&C PureWave® Community Energy Storage System

25 kW units

Local backup power for consumers

Distributed voltage and frequency control

Multiple units scalable

Distributed Energy Storage

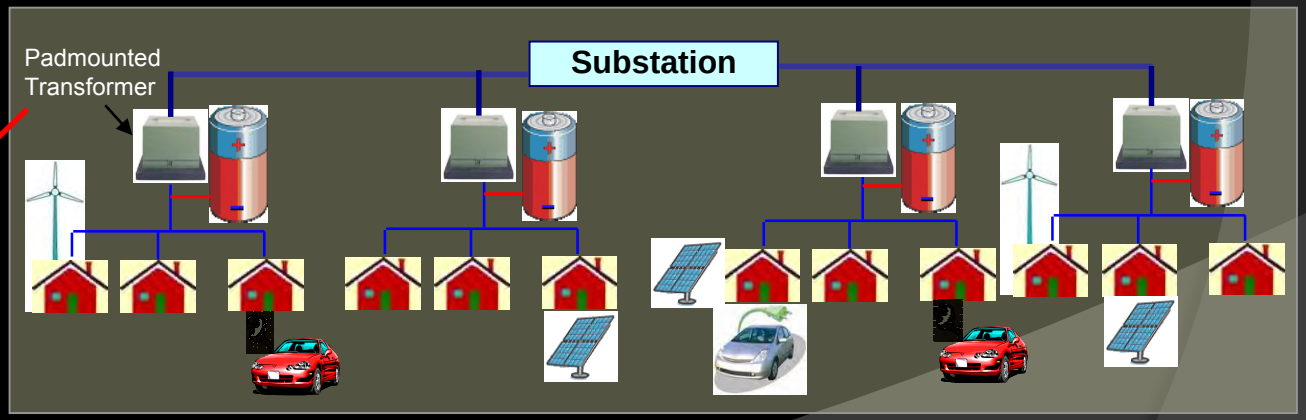
Improved service reliability and efficiency (close to loads)

Voltage sag mitigation and emergency transformer load relief

Multi-MW, Multi-hour ***when aggregated***

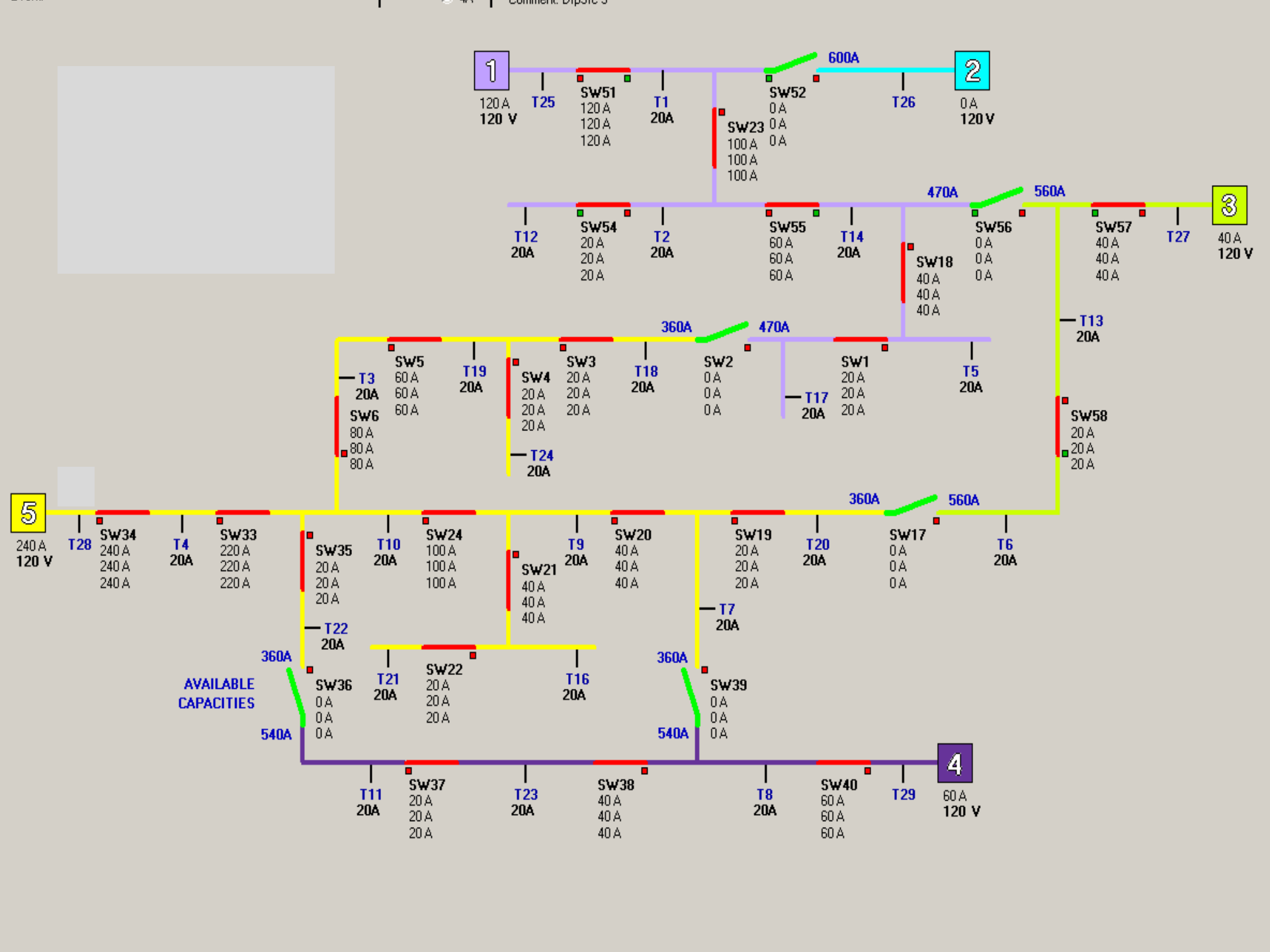
Synergy with PHEV

Generation source to which solar panels can sync



What's Needed to Implement a Microgrid?

- Alternate energy sources
- Energy storage
  - Smooth renewable output
  - Frequency and VAR support
- **Equipment and controls to achieve**:
  - Automatic fault isolation and service restoration
  - Automatic islanding


1
120 A
120 V
T25
SW51
120 A
120 A
120 A
T1
20A
SW23
100 A
100 A
100 A
600A
SW52
0 A
0 A
0 A
T26
2
0 A
120 V
470A
560A
T12
20A
SW54
20 A
20 A
20 A
T2
20A
SW55
60 A
60 A
60 A
T14
20A
SW18
40 A
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40 A
SW56
0 A
0 A
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SW57
40 A
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40 A
T27
3
40 A
120 V
T13
20A
360A
470A
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80 A
80 A
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SW5
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T19
20A
SW4
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SW3
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SW2
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T17
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SW1
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T5
20A
SW58
20 A
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20 A
5
240 A
120 V
T28
SW34
240 A
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SW33
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SW35
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SW22
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20A
360A
SW39
0 A
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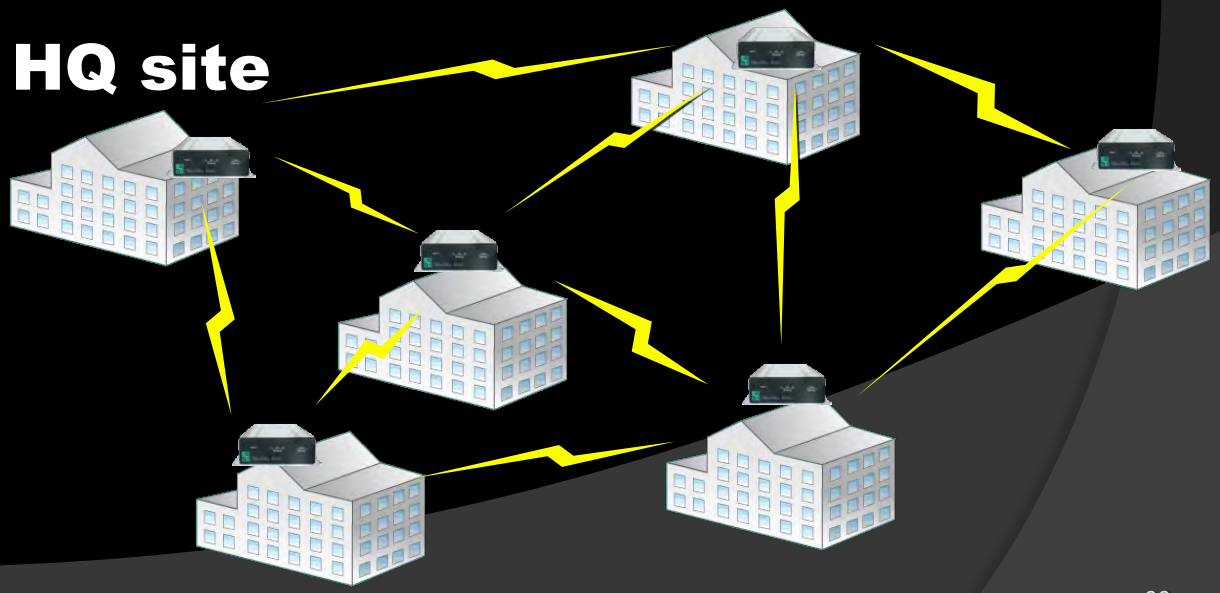
540A
540A
4
60 A
120 V
T11
20A
SW37
20 A
20 A
20 A
T23
20A
SW38
40 A
40 A
40 A
T8
20A
SW40
60 A
60 A
60 A
T29

What's Needed to Implement a Microgrid?

- Alternate energy sources
- Energy storage
  - Smooth renewable output
  - Frequency and VAR support
- Equipment and controls to achieve:
  - Automatic fault isolation and service restoration
  - Automatic islanding
- **Reliable, high-speed communication to enable these functions**

Radio Architecture : Mesh

- No single point congestion
- Highest possible reliability
- No single point of failure
- Networks continually evaluate and select best path
- Throughputs are path dependent, not master site dependent



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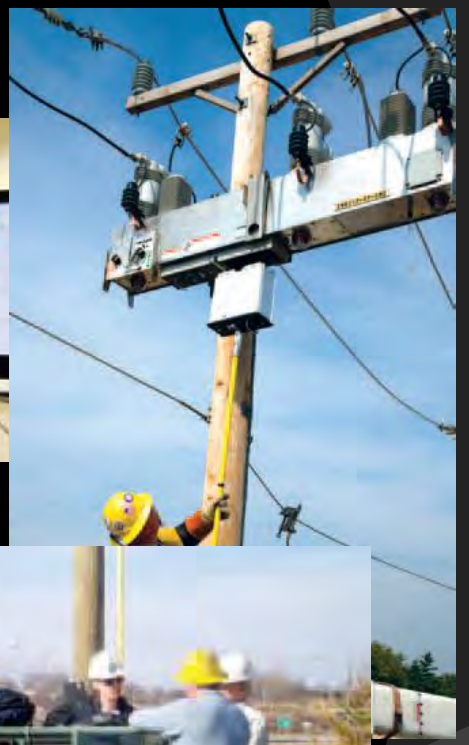
- Reliable, high-speed communication to enable these functions
- Control systems for distributed resources and demand reduction
- **Expertise in planning, designing, and constructing microgrids**

Moving forward

- Identify critical areas
  - Mission critical`
  - Research facilities
  - Life safety areas
- Determine method of protecting services
  - Coordinate with local utilities
  - Speed of transfer
  - Local generation facilities existing/needed
  - Coordination of local resources-microgrid
- Evaluate alternatives
  - Supplier discussions
  - Visit existing installations

Typical Microgrid Services Required

- Analysis of existing distribution system
- Load flow, coordination, and arc-flash hazard studies
- Microgrid design
- Adaptation of existing equipment
- Communication system design
- Equipment procurement
- Coordination with local authorities
- Construction management
- Asset management



S&C Smart grid and Microgrid Portfolio

Smart Switching

Geospatial Information System

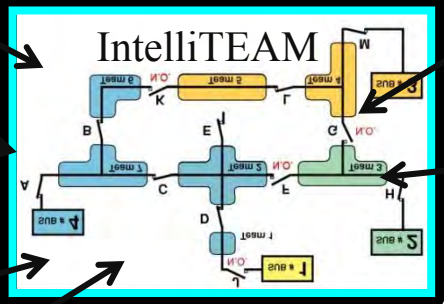
Network Data

Communications

Existing Switching Devices: upgrade to distributed intelligence

Substation based

Energy Storage – MV and LV



Device based

Status & Data

SCADA switches

Renewables

Pad Mounted Switches

Grid Control Center

Questions?

Don Dumich
Application Director-C&I
S&C Electric Company
www.sandc.com