
City of Bellevue 2017 Electric System Reliability Review



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October 12, 2018

Introductions

- Andy Swayne – Senior Municipal Liaison Manager
- Bill Foster – Regional System Reliability Planner – North
- Ray Hisayasu – Regional System Planning Supervisor - North
- Chris Yoon – Transmission System Planner
- Cathy Koch – Director Planning
- Kevin Gowan – Asset Management Supervisor
- Elaine Markham – Smart Grid Planning Manager
- David Hoffman – Local Government Relations Manager
- Keri Pravitz – Community Projects Manager

Workshop Purpose

- Provide an overview discussion of PSE electrical system performance in 2017 as reported to the City
 - Overall performance
 - Reliability projects completed and proposed
 - Automation initiatives (Smart Grid)
 - Information technology initiatives

2017 Bellevue Reliability Overview

Bellevue is served by 96 distribution circuits from 23 substations

63 circuits (66%) had performance better than our system wide average

16 circuits (17%) experienced no unplanned outages

33 circuits (34%) had performance below our system wide average

The CBD is served by 24 distribution circuits from 4 substations

7 reliability circuits provide redundancy for downtown customers

There were 2 unplanned outage events which affected downtown customers in 2017:

- A junction box & cable elbow failure caused a local outage
- A highline switch malfunction briefly deenergized Clyde Hill & Lochleven substations (equivalent to circuit outages)

2017 Bellevue Reliability Overview

Electric Service Reliability Reporting to the WUTC

- PSE reports service performance in multiple calculations.
- Service Quality Indices (SQI) SAIDI & SAIFI values are used to measure performance against established threshold values:

System Average Interruption Duration Index [SAIDI] SQI 155

Total customer outage minutes / average total customer count

System Average Interruption Frequency Index [SAIFI] SQI 1.3

Total customers affected / average total customer count

- WUTC lists SAIDI_{IEEE} & SAIFI_{IEEE} figures for PSE and other electric utilities at its website:

utc.wa.gov/regulatedIndustries/utilities/energy/Pages/electricReliabilityReports.aspx

Click the blue link values to see full annual reports including all calculations formats

2017 Bellevue Reliability Overview

Bellevue performance SAIDI_{sqi} & SAIFI_{sqi} in comparison to PSE system wide performance SAIDI_{sqi} & SAIFI_{sqi}

SYSTEM AVERAGE INTERRUPTION DURATION INDEX (SAIDI) & SYSTEM AVERAGE INTERRUPTION FREQUENCY INDEX (SAIFI) FIVE YEAR HISTORY

SAIDI figures in minutes, all outages including storm
SAIFI figures in outage events, all non-storm outages

	SAIDI		SAIFI	
	BELLEVUE	PSE	BELLEVUE	PSE
2013	100.7	247.0	0.41	0.86
2014	160.2	312.0	0.60	1.04
2015	186.9	361.0	0.71	1.11
2016	107.0	148.0	0.74	1.06
2017	116.4	175.0	0.91	1.20

PSE SAIDI figures for 2013 - 2015 are five year rolling average figures.

The 2013 Bellevue SAIDI figure was calculated as a four year rolling average for years 2010 - 2013.

The 2014 - 2015 Bellevue SAIDI figures were calculated as a five year rolling average figures.

2016 - 2017 SAIDI figures were calculated a single year IEEE 1366 method figures.

2017 Bellevue Reliability Overview

SAIDI IEEE 1366 calculation – why did we switch?

- PSE's prior method of calculating SAIDI_{SQI} was based on estimated outage size reported in a legacy system.
- Since 2013 an Outage Management System (OMS) allows calculation of outage event duration with more precise customer counts capturing and reporting outage minutes more accurately.
- In 2016 PSE's SAIDI_{SQI} reporting switched to industry standard IEEE 1366 calculation used by most utilities.
- IEEE 1366 characteristics:
 - A sustained outage event is defined as 5 minutes or greater
 - Outage events occurring during Major Event Days are excluded
 - Calculation provides single calendar year figures
- The WUTC agreed that the IEEE 1366 methodology would provide improved understanding and reporting of outage events affecting PSE customers.

2017 Bellevue Reliability Overview

Bellevue circuits with SAIDI or SAIFI exceeding system wide figures

CIRCUITS THAT EXCEED 2017 PSE SYSTEM SAIDI AND/OR SAIFI			Notes: SAIDI figures reflect all non-med, scheduled & unscheduled; SAIFI figures reflect all non-storm outages, scheduled & unscheduled	
2017 Events Comments			Planned Actions & Projects	
Circuit	SAIDI	SAIFI	2017 Events Comments	Planned Actions & Projects
Circuits with planned actions or investigations				
NLU-27	621.4	3.87	Multiple planned and unplanned outages occurred during relocation of overhead feeder lines in coordination with the Sound Transit East Link project construction along NE Spring Blvd and 156th Pl. Hill. One outage was caused by a contractor digging into underground cables. Another outage occurred when overhead lines sagged together during contractor excavation close to a distribution pole. A tree fell into the overhead feeder causing a circuit outage. A water main break damaged a pole resulting in a sustained outage (the area had to be isolated before PSE response could proceed).	PSE responded to each situation and restored service. Relocation of PSE overhead lines is complete. PSE continues to coordinate ongoing construction in proximity to PSE facilities with Sound Transit and to contractor.
EST-28	424.0	1.41	A tree fell into the overhead feeder causing a circuit outage. A water main break damaged a pole resulting in a sustained outage (the area had to be isolated before PSE response could proceed).	The damaged distribution pole was replaced.
EST-12	519.6	3.93	Wind blew a tree into Estgate Bank 1 damaging the 12.5 kV bus causing causing the substation transformer to denigrate. Wind and pole caused trees and lines to lean into overhead lines causing multiple outages.	Customers were picked up from surrounding circuits while the damage in the substation was being repaired; the transformer bank was tested and the substation was returned to service. A PSE tree crew performed a hazard assessment identifying problem trees which were trimmed back.
FAC-12	238.0	2.43	A cable failure caused a large sustained outage in the Woodbridge area. Localized cable failures also played a role.	The faulted feeder cable was replaced and the local cables were repaired pending development of a cable replacement project.
NOB-24	223.7	1.22	A cable fault caused a circuit outage.	The faulted cable was repaired.
LMU-26	162.2	0.96	Three localized outages in the underground system occurred.	The failed equipment was replaced.
Circuits with completed 2017 actions - no additional corrective action needed				
LOC-32	486.8	1.77	A transmission line operation on April 11th impacted Lochvein Substation and six other substations for 6 minutes. An equipment failure resulted in multiple customers at Union Square - ongoing development construction limited access to facilities and extended restoration response and repair time.	Failed equipment was replaced.
KWH-23	464.3	3.30	Cable faults caused outages in the underground feeder and an additional outage occurred when a tree impacted the overhead feeder.	The underground feeder cables were replaced.
LOC-33	427.1	1.86	A transmission line operation on April 11th impacted Lochvein Substation and six other substations for 6 minutes. A scheduled overnight outage was taken to support development in the Bellevue CBD.	
COL-22	416.0	1.00	A customer requested a scheduled outage to allow their contractor to work on the customer owned electrical system safely.	
OVB-16	326.3	2.64	A difficult to locate distribution cable failure caused a sustained outage. An equipment failure damaged a pole resulting a sustained outage to safety reduce the pole and equipment.	Cables were replaced. Pole and equipment was replaced.
EST-11	284.2	1.36	Wind blew a tree into Estgate Bank 1 damaging the 12.5 kV bus causing causing the substation transformer to denigrate.	Customers were picked up from surrounding circuits while the damage in the substation was being repaired; the transformer bank was tested and the substation was returned to service.
EVB-23	238.4	1.20	A cable fault caused a circuit outage. A scheduled outage was required for a planned pole replacement.	The underground feeder work has been scoped and the design is in progress.
KWH-26	236.0	1.24	There were two local outages in the underground system that required extended time to locate the problems, isolate them and restore service.	Repairs were made and the failed equipment replaced.
EST-16	224.7	1.33	Wind blew a tree into Estgate Bank 1 damaging the 12.5 kV bus causing causing the substation transformer to denigrate.	Customers were picked up from surrounding circuits while the damage in the substation was being repaired; the transformer bank was tested and the substation was returned to service.
GEN-21	221.5	0.42	A planned outage was scheduled to a nearby building so that it could be tied in to the new system being built for a new customer project.	
ARD-11	219.2	0.74	A planned outage was scheduled to four buildings along Ben Reed Road so that PSE could extend new system for a new customer project.	
COL-24	217.1	1.00	An underground system equipment failure caused a sustained outage.	Failed equipment was replaced.
EST-13	192.9	1.00	Wind blew a tree into Estgate Bank 1 damaging the 12.5 kV bus causing causing the substation transformer to denigrate. An animal contact damaged equipment causing a 3.5 hour outage to a group of multi-family residences.	Customers were picked up from surrounding circuits while the damage in the substation was being repaired; the transformer bank was tested and the substation was returned to service. The damaged equipment was replaced.
ARD-16	187.1	0.47	A feeder cable failure caused a circuit outage.	The failed cable was replaced.
BTR-21	176.1	1.22	Wind blew a tree into Estgate Bank 1 damaging the 12.5 kV bus causing causing the substation transformer to denigrate.	Customers were picked up from surrounding circuits while the damage in the substation was being repaired; the transformer bank was tested and the substation was returned to service.
EST-15	167.2	0.78	A cable failure and an equipment failure caused two outages. A customer requested restoration work be deferred to occur after business hours.	Failed cables and equipment were replaced.
GEN-11	156.4	0.37	A tree fell through overhead feeder lines and damage equipment on a pole during a local weather event.	The system was restored through switching and the damaged equipment was repaired/replaced.
PWA-13	148.4	1.30	A tree fell into overhead feeder causing a circuit outage (KWH-23 & KWH-26) were tied together and experienced the same outage event.	
KWH-26	142.4	1.36	A transmission line operation on April 11th impacted South Bellevue Substation and six other substations for 6 minutes. A bad mount switch failed causing a circuit outage. Construction of a reliability project required planned outage to customers.	The failed pad mount switch was replaced, and the reliability project for Sully Downs neighborhood was completed.
DBB-23	140.1	4.88	A transmission line operation on April 11th impacted South Bellevue Substation and six other substations for 6 minutes.	
DBB-26	85.9	1.82	A transmission line operation on April 11th impacted South Bellevue Substation and six other substations for 6 minutes.	
LOC-22	84.9	1.46	A transmission line operation on April 11th impacted Lochvein Substation and six other substations for 6 minutes.	
CLY-27	75.4	2.86	A transmission line operation on April 11th impacted Clyde Hill Substation and six other substations for 6 minutes. A circuit outage occurred when a squirrel made contact with an energized cable termination.	The termination was rebuilt.
HOU-23	74.6	1.20	A transmission line operation on April 11th impacted Houghton Substation and six other substations for 6 minutes.	
MED-26	67.7	1.27	A transmission line operation on April 11th impacted Medina Substation and six other substations for 6 minutes.	
DBB-22	39.9	1.29	A transmission line operation on April 11th impacted South Bellevue Substation and six other substations for 6 minutes.	
HOU-26	27.9	1.24	A transmission line operation on April 11th impacted Houghton Substation and six other substations for 6 minutes.	

- 33 circuits had SAIDI or SAIFI in 2017 exceeding system wide figures. 27 of these circuits have been addressed or require no corrective action. The remaining 6 circuits have improvement actions identified or under review.



2017 Bellevue Reliability Overview

Circuits Exceeding System SAIDI and/or SAIFI 2013 – 2017

CIRCUIT	Repeat Counts					1	2	3	4
	2013	2014	2015	2016	2017				
ARD-11					1		2		
ARD-15	1		1		1			3	
BTR-21					1	1			
BTR-22	1	1	1					3	
SOM-13	1	1					2		
SOM-15	1		1				2		
SOM-16		1	1	1				3	
SOM-17			1	1			2		
Totals	21	25	23	22	33	30	22	10	5
	2013	2014	2015	2016	2017	45%	33%	15%	7%

67 circuits have exceeded system wide average performance during this period ...

- 30 (45%) once in five years
- 22 (33%) twice in five years
- 10 (15%) three times in five years
- 5 (7%) four times in five years

2017 Bellevue Reliability Overview

A list of performance for circuits serving Bellevue

2017 PERFORMANCE FOR CIRCUITS SERVING BELLEVUE

CIRCUIT	CUSTOMERS (METERS)	UNPLANNED OUTAGES ¹	UNPLANNED	SAIDI ²	SAIFI ²
			OUTAGE MINUTES ¹		
	<i>2017 PSE Companywide performance figures</i>			175	1.2
ARD-11	216	0	0	219.16	0.74 ⁴
ARD-13	634	1	782	9.44	0.02
ARD-15	1,293	4	219,740	187.09	0.47
ARD-43	10	0	0	0.00	0.00
BTR-14	1,136	4	10,230	22.16	0.07
BTR-21	1,135	6	194,060	175.08	1.22
BTR-22	647	8	20,364	138.73	0.36
BTR-23	643	0	0	0.00	0.00

Notes

- 1 Figures exclude Major Event Day & Major Storm outages.
- 2 SAIDI are 2017 single year figures calculated using the IEEE 1366 method which excludes Major Event Day outage events.
SAIFI are 2017 single year figures which exclude 5% Exclusion Major Event Day outage events.
- 3 Includes one circuit outage resulting from substation bank outage.
- 4 SAIDI & SAIFI figures greater than zero reflect inclusion of scheduled outages (including customer requested outages).

2017 Bellevue Reliability Overview

Summary analysis by outage cause and equipment involved

CAUSE CODE	CAUSE DESCRIPTION	OUTAGES		OUTAGE MINUTES	
		COUNT	PERCENT	COUNT	PERCENT
AC	ACCIDENT	14	2.7%	244,527	3.2%
BA	BIRD OR ANIMAL	85	16.1%	712,278	9.3%
CE	CUSTOMER EQUIPMENT	3	0.6%	1,061	0.0%
CP	CAR EQUIPMENT	5	0.9%	33,927	0.4%
DU	DIG UP UNDERGROUND	13	2.5%	14,428	0.2%
EF	EQUIPMENT FAILURE	223	42.3%	2,969,613	38.7%
FI	FAULTY INSTALLATION	11	2.1%	1,226	0.0%
LI	LIGHTNING	11	2.1%	1,015,172	13.2%
OD	OUTSIDE DISTURBANCE	2	0.4%	10,199	0.1%
OE	OUTAGE WHILE WORKING	1	0.2%	12,427	0.2%
TV	TREE - RIGHT OF WAY UNKNOWN	71	13.5%	2,043,920	26.6%
UN	UNKNOWN CAUSE	88	16.7%	618,134	8.1%
Totals		527	100%	7,676,912	100%

EQUIP CODE	EQUIPMENT DESCRIPTION	OUTAGES		OUTAGE MINUTES	
		COUNT	PERCENT	COUNT	PERCENT
OAR	OVERHEAD ARRESTER	2	0.4%	53,960	0.7%
OCE	CUSTOMER EQUIPMENT	2	0.4%	305	0.0%
OCN	OVERHEAD SECONDARY CONNECTOR	11	2.1%	3,275	0.0%
OCO	OVERHEAD CONDUCTOR	64	12.1%	2,067,183	26.9%
OCR	OVERHEAD CROSSARM	5	0.9%	29,613	0.4%
OFC	OVERHEAD CUT-OUT	5	0.9%	11,282	0.1%
OFU	OVERHEAD LINE FUSE / FUSE LINK	33	6.3%	101,237	1.3%
USV	UNDERGROUND SERVICE	84	15.9%	26,007	0.3%
UTC	UNDERGROUND TERMINAL FUSE	31	5.9%	244,606	3.2%
UTF	UNDERGROUND SUBMERSIBLE TRA	2	0.4%	1,653	0.0%
UTR	UNDERGROUND SUBMERSIBLE TRANSFORMER	30	5.7%	462,060	6.0%
UNK	UNDERGROUND UNKNOWN	5	0.9%	25,123	0.3%
Totals		527	100%	7,676,912	100%

2017 Bellevue Reliability Overview

A tabular listing of outage events on circuits serving Bellevue

2017 OUTAGES FOR CIRCUITS SERVING BELLEVUE

EXCLUDING CUSTOMER REQUESTED & SCHEDULED OUTAGES

DATE	CIRCUIT	CAUSE	EQUIPMENT	CUSTOMERS OUT	CUSTOMER MINUTES	STORM CODE
12/22/2017	ARD-13	UPT	CP	2	782	NON
1/30/2017	ARD-15	UOT	BA	206	56,672	NON
7/26/2017	ARD-15	UTR	EF	4	1,238	NON
8/13/2017	ARD-15	UTR	EF	118	23,705	NON
8/24/2017	ARD-15	UTC	BA	207	138,125	NON
1/7/2017	BTR-14	UEL	EF	54	8,646	NON
1/24/2017	BTR-14	UPC	EF	18	41	NON
1/24/2017	BTR-14	UPC	EF	6	1,054	NON
5/27/2017	BTR-14	UGF	CE	2	489	NON
2/9/2017	BTR-21	OCO	TV	1	779	MEJ
3/10/2017	BTR-21	OCO	TV	13	3,126	NON
3/23/2017	BTR-21	UPC	EF	1,135	163,008	NON
Totals				117,013	30,945,626	
Substation and transmission outages				21,342	1,062,320	

- 1 Damage to transmission switch
- 2 Tree in Substation

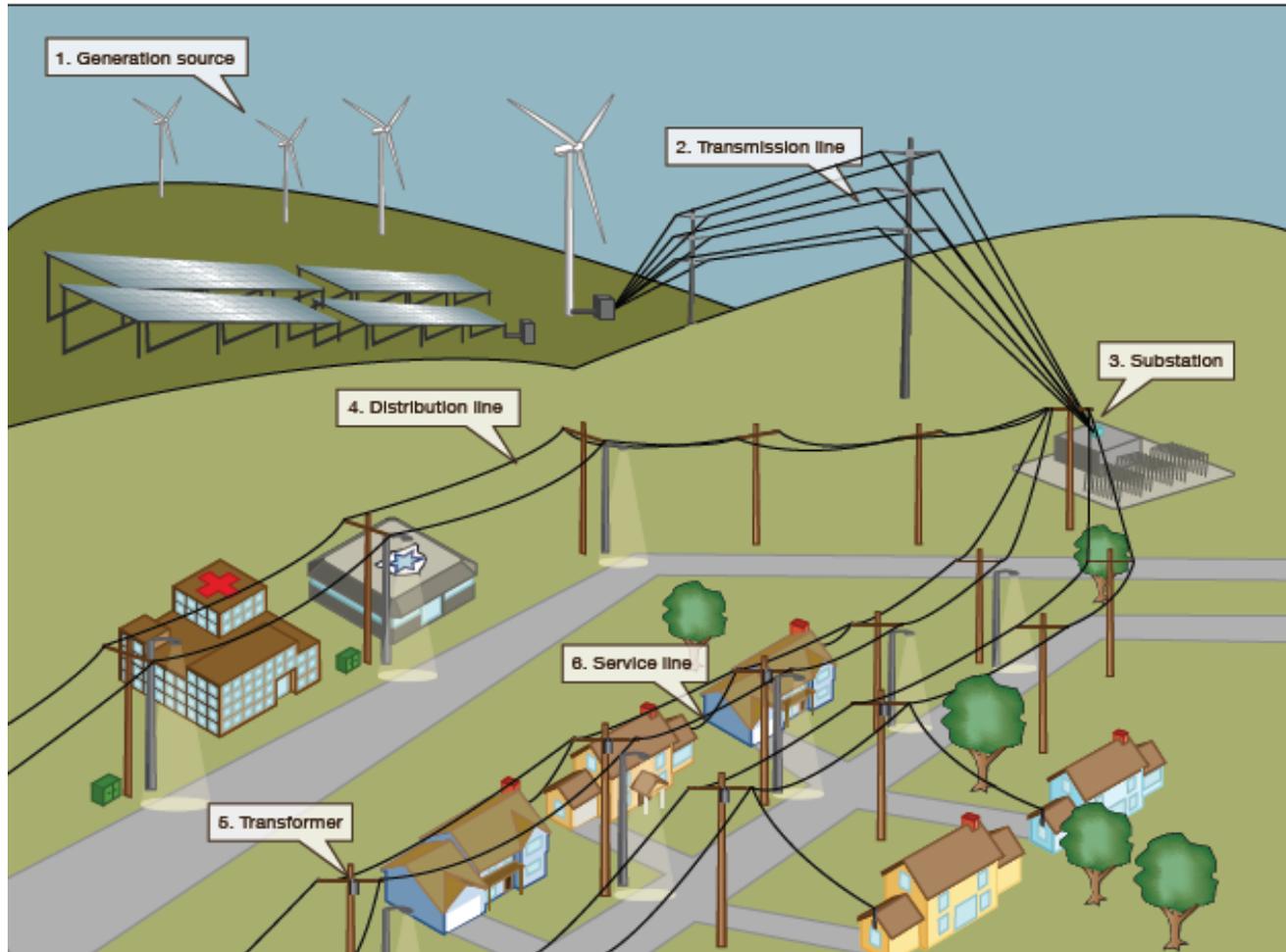
MEJ Not included in SAIDI or SAIFI calculations

MEN Not included in SAIDI calculation, included in SAIFI calculation

NMJ Included in SAIDI calculation, not included in SAIFI calculation



How Power Gets To You



Substations, Circuits & Neighborhoods

- Transmission lines bring power to substations
 - Substations distribute power in surrounding areas by circuits
 - Circuits bring power to homes and businesses
 - Substation and circuit locations and configurations are primarily determined by electric load distribution – not by geographic boundaries
-
- Neighborhoods define geographic areas
 - Neighborhoods are served by multiple substations & circuits
 - Substations and circuits serve multiple neighborhoods
-
- PSE assesses system performance by circuits, not by neighborhoods – just like other utilities

Performance Response Approaches

- Performance improvement can take many approaches including ...
 - Increasing vegetation trimming clearance and/or frequency
 - Selective vegetation removal and replacement
 - Tree wire installation
 - Switch and recloser installations
 - Animal resistant equipment and configuration changes
 - Distribution system overhead to underground conversions
 - SCADA additions and Distribution Automation
 - Underground distribution cable replacement
 - Equipment monitoring, trend analysis and programmatic replacement
- Find out more at:
 - [PSE.com/system-reliability/electric-reliability](https://www.pse.com/system-reliability/electric-reliability)
 - [PSE.com/pages/tree-trimming/about-the-program](https://www.pse.com/pages/tree-trimming/about-the-program)

Reliability Projects Completed in 2017

- Distribution cable replacement projects in the Crossroads area (programmatic replacements planned to continue into 2019)
- 11 cable replacement projects (various circuits – 21,000 circuit feet) including proactive replacements
- Vegetation management trimming of 4 distribution circuits and 4 transmission lines

Proposed Distribution Reliability Projects

- Mark 1 Switch replacement in the Cherry Crest Neighborhood
- Installation of Reclosers on Eastgate 28 and South Bellevue 22 feeder circuits
- Tree wire retrofit projects on Eastgate 12 (in construction), Kenilworth 23 (just completed)
- Bridle Trails 22 feeder undergrounding west of 140th AVE NE
- Distribution cable replacements in Crossroads area (continuing) via the Cable Remediation Program in locations where new conduit is needed
- 26 cable replacement projects engineered for future construction (84,000 circuit feet)
- 4 cable replacement projects scoped for future engineering (20,000 circuit feet)

Transmission System Improvements

- Completed ...
 - Lakeside 115 kV Switching Station Rebuild– completion in 2017.
- In Progress ...
 - Lake Hills – Phantom Lake 115kV – New transmission line between existing substations to provide redundant looped transmission connection for three substations – expected to begin construction in early 2019.
 - Energize Eastside 230kV – Upgrading transmission lines along existing corridor and build a new transmission substation in Bellevue to provide increased system capacity and reliability for Bellevue and the greater Eastside – currently in permitting with expected construction in 2019.
- NEW* • Shuffleton – Lakeside 115kV SCADA Upgrade – Upgrading existing highline switches to provide switch automation north and south of Somerset Tap 115kV to improve transmission system response to faults.
- On the Near Horizon ...
 - Vernell Substation – New 115kV transmission switching station for improved transmission system flexibility/reliability with new distribution system capacity to support Spring District development in 2023.

Smart Grid Initiatives Including Automation

- Advanced Meter Infrastructure (AMI) – Network installation is complete in Bellevue. Approximately 90 percent of Bellevue electric meters have been replaced with expected completion of all Bellevue electric meter replacement in 2019. Learn more at pse.com/pages/meter-upgrade.
- Distribution Automation (DA) – 22 projects will have been constructed at the end of 2018 with 7 more planned for 2019.
- Distribution SCADA Switchgear – 66 switches in the CBD area get SCADA and EMS integration to allow system operators to see the distribution system configuration and respond to events in real time. 36 switches installed. 5 switches expected to be retrofit in 2018. 7 switches proposed for retrofit in 2019. Current target date for program completion in 2023. This is precursor to work for CBD DA implementation.
- Battery Storage – 3 demonstration projects to evaluate best use of evolving battery storage technologies applications including utility scale batteries and distributed batteries. Learn more at pse.com/pages/smart-grid.

Distribution Automation

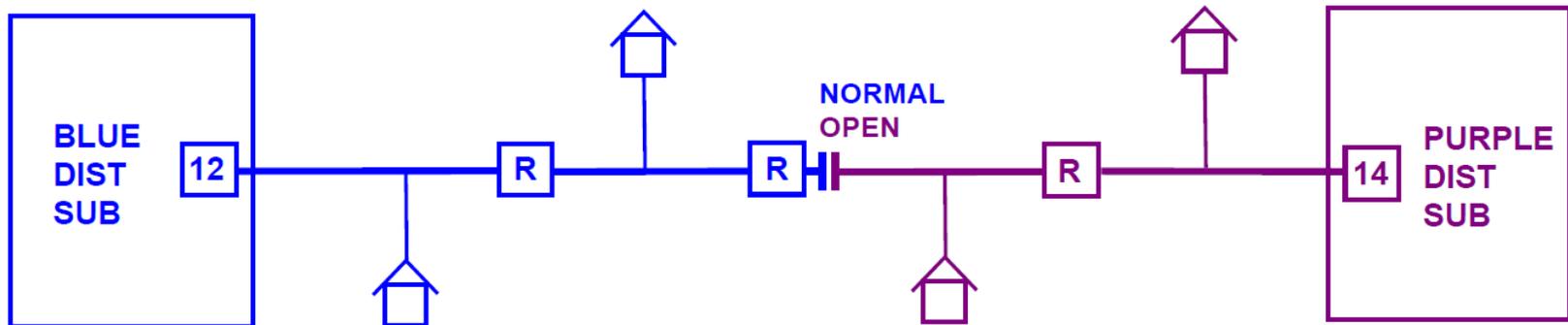
- Distribution Automation (DA) can provide a level of self-healing response to distribution system outage events using SCADA equipped devices and automated control software.
- DA isolates faults through switching, then attempts to restore power outside of the faulted (isolated) area. Fewer customers experience a sustained outage while more customers can see their power restored in under five minutes.
- To be effective DA requires a robust and redundant transmission system to keep power flowing to distribution substations
- DA control software must be integrated with other electric system control systems including Outage Management System (OMS) and Energy Management System (EMS).

Distribution Automation

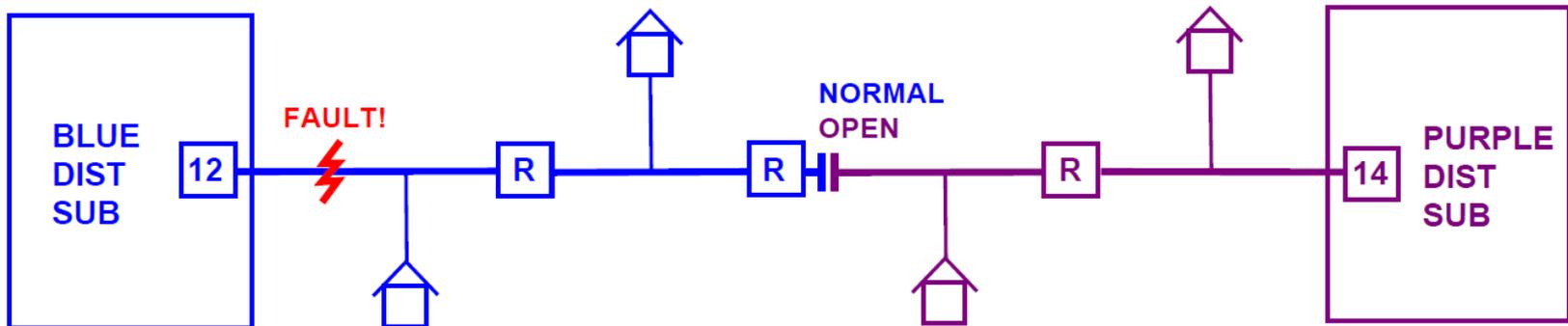
- PSE has implemented Feeder Automation (FA) software to interface with our Outage Management and Energy Management Systems.
- PSE has reviewed system wide performance to identify initial locations to best test and assess the efficacy of FA focusing on areas with frequent and/or prolonged outages.
- As efficacy of these projects is assessed additional DA projects are developed for construction using a prioritized programmatic approach.
- Our first DA implementation in Bellevue is currently in planning involving distribution feeder circuits fed from our Eastgate, Somerset & Hazelwood substations in the South Bellevue area with deployment targeted for 2020.

Distribution Automation

How Distribution Automation works. Example of two feeders fed from two different substations with a normal open recloser that can tie them together

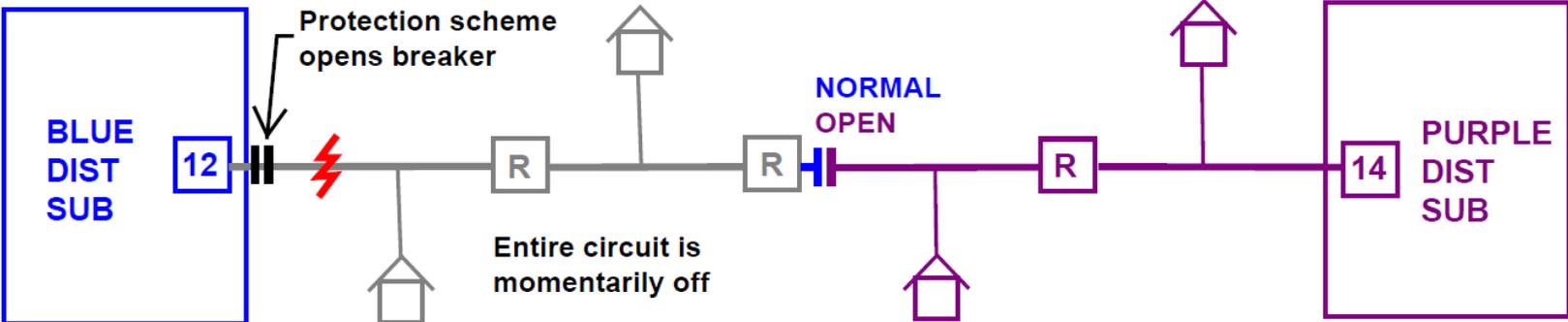


The blue circuit experiences a fault ...

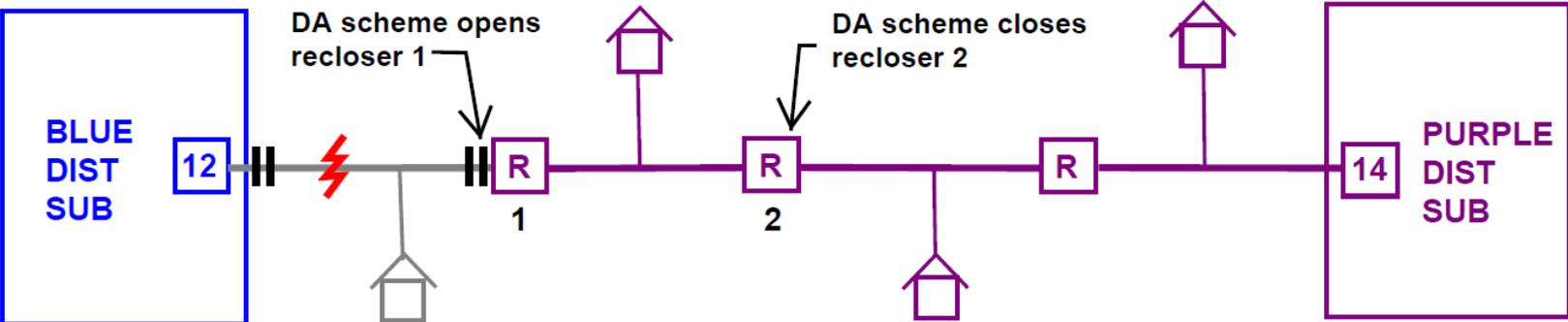


Distribution Automation

Responding to the fault the DA protection scheme opens the blue circuit breaker at the substation resulting in a momentary blue circuit outage

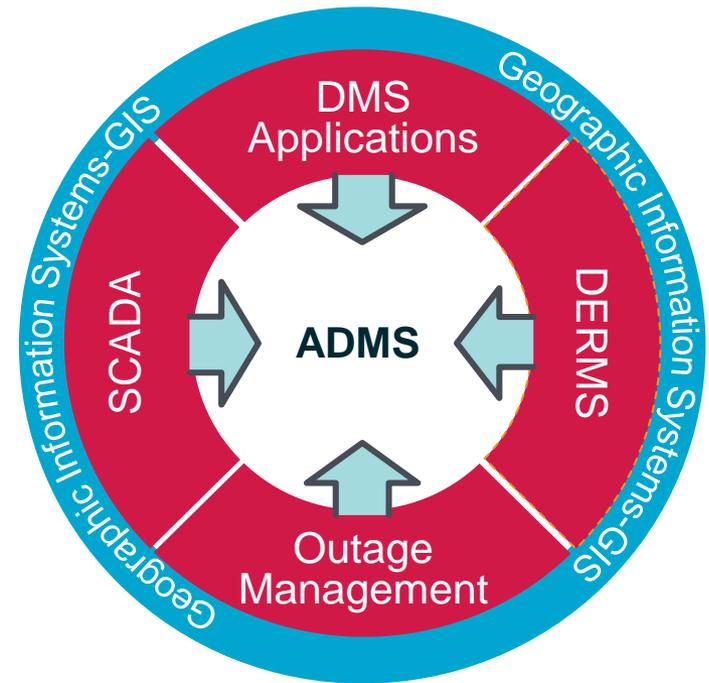


The DA scheme isolates the fault by opening recloser 1 and closing recloser 2 to restore power to customers using the purple feeder circuit



Advanced Distribution Management System

- ADMS is a computer based decision support system used to supervise, manage and control the real-time operations of the distribution system network.
- PSE signed a contract in July 2018 to implement an ADMS.
- The ADMS platform is expected to be fully deployed in 2021.
- ADMS will eventually replace our current OMS & FA (DA) platforms.



DERMS: Distributed Energy Resources Management System
SCADA: Supervisory Control & Data Acquisition

Wrapping Up

Questions & Discussion