Denny Substation:
Innovation and Teamwork

Presentation for MIPSYCON 2019

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Project Site: 1928
Project Site: 1931
Project Site: 1960’s
Project Site: Today
Project Site at Purchase
Justification Report: Original Rendering

Substation Facing Southwest
Remediation of Grayhound Facility
Pre-Construction
Project Site: Today

Proposed Denny Substation Site

Existing Broad Street Substation
Background

- Seattle Central Park Initiative
- Zoning changes led to high density load growth.
- Amazon HQ moves to SLU
- A consultant was hired to evaluate load growth and recommend a course of action.
  - A study (pre-Amazon high rises) recommended building a new substation with new 13.8 kV network
  - Substation is expandable to 230kV with 12 more 13.8kV feeders and additional 26 kV feeders for future load growth/network reinforcement
We All Saw A Great Substation Project

- New 115-13.8 kV Substation with all UG lines/feeders
- 3.5 miles of 13.8 kV duct bank
- 115 kV GIS Substation
- 13.8 kV Feeders (30ish)
- Future 230 kV, 26 kV
- 115kV HPFF Line Cuts Site
- Blah, blah, blah…..snore
The new substation needed to fit into a dense, urban environment.

- Urban Projects Are Expensive
- Compact Design Challenges
- Scheduling & Planning
- Community Impact
- Street Vacation
- Urban Design Merit
- Challenges to Electrical Load Density
- Site contamination
...With Unique Challenges

1. Political Environment
2. Incomplete EIS at the Start of Design
3. Public Outreach & Community Involvement
4. Survey & Existing Utilities
5. Street Vacation & Public Benefit
6. Sustainability
7. Need for Art
8. Technical Difficulty
9. Site Activation
10. Many Teams
**With Unique Challenges**

- Network system distribution transformers have secondaries connected together.
- Cannot split 15 kV bus was a design criteria.
- Distribution vaults equipment rated for 25kA.
- Solution based procurement for electrical equip.
- Voltage Collapse in N-1.
- Network loop flow.
- 15kV bus topology?
- 115kV loop flow.
1. Political Environment

This project attracted a lot of attention

- City Council & Mayor – Elected Officials
- Seattle Design Commission (SDC) Capital Projects – Appointed by Mayor
- Neighbors and Street Vacation
- Numerous involved City of Seattle Departments
- Seattle is an involved & politically active community
- Over 70 stakeholders for the project, 20 primary
2. Incomplete EIS at the Start of Design

The City of Seattle decided to perform an Environmental Impact Statement (EIS)

- Aesthetics
- Noise
- Electric & Magnetic Fields
- Hazardous Materials
- Transportation
- Land Use & Housing
- Green Streets
- Public Services
- Energy & Natural Resources
- T/L Preferred Route?

- Historic & Cultural Resources
- Air Quality & Greenhouse Gases
- Water Resources
- Utilities
3. Public Outreach & Community Involvement

- Conducted public surveys
- Public meetings
- Design & updates
  - Public hot-line to leave messages
  - Public emails
  - Facebook, Twitter, YouTube, LinkedIn, RSS
- Project brochures, mailings & notices
- Coordinated between SCL and Design Team
- Open approach driven by public input
Alternative Considerations

• The key factors for a successful project had to be carefully considered
• The presented alternatives are technically sound, constructible, maintainable, safe & meet the needs of the community
• Three unique designs, two sites with a look at co-development, one site without Street vacation.
• Co-development was no go
• Alternate site analysis
Alternative Considerations

Three unique alternates
Land Use

9-block study area

- Community
- Commercial
- Residential
- Parks & Open Space
- Parking
- Green Streets
- Comprehensive Plans
- Neighborhood Plans
4. Surveys & Existing Utilities

Provide accurate documentation of subgrade for design & minimize construction COs.

- Necessary to document for the contractors
- Still found rail tracks, side sewers, etc.
- 3-D location of utilities
  - Field survey & research of as-built records
  - Potholing for in key areas
  - Water, sewer, storm, gas, cable, telephone, fiber optic
  - Curbs, gutters, manhole lids, underground pipes
  - 30” brick water main
5. Street Vacation & Public Benefit

When a street is closed, the public loses parking & access in the immediate area. As a result, offsetting public benefit is required from the project.

- Playgrounds
- Skateboard Park
- Off Leash Dog Park
- Pea Patch
- Food Truck Access
- Art
- Public Wi-Fi

- Bicycle Amenities
- Car Charging Stations
- Improved Lighting
- Pedestrian Experience
- Learning Center
- Community Facility
- Underground Utilities
6. Sustainability

**Site Sustainability:**
- Brownfield Redevelopment
- Reduce Stormwater Runoff
- Drought Tolerant Landscape
- Reduce Irrigation Demand
- Bioretention Planters

**Building Sustainability:**
- Renewable Energy
- Reduced Building Heat Gain
- Building Material Efficiencies
- Solar Panels
- Reduced Urban Heat Island

**Promote Sustainability:**
- Equitable Site Use
- Encourage Mass Transit
- Promote Sustainability Awareness
- Heat Recovery
6. Sustainability Considerations

Sustainability

• The City of Seattle requires elements of sustainability on capital improvement projects.
• The Seattle Design Commission reviews projects with sustainability as a requirement.
• The design team was instructed to look for opportunities for sustainability (create a Sustainability Plan) & integrate those into the project where practical.
Other Innovative Ideas

- Public meeting space.
- Learning Center, coffee shop, library, police?
- Brewster building historical site protection.
- 40 kW solar panels – feeds station service.
- Distribution vault basement heat recovery system.
- Combined GIS-reactor to save space.
- Site drains into site oil containment system.
- Corporate commitment: Public input shall drive the process. In sometimes unexpected ways.
The City of Seattle puts 1% of their capital budgets into art projects but funded out of O&M.

“Transforest”
On Completion?
On Completion
On Completion
On Completion?
7. Art

Wind Activated LED Array

PROPOSED ART ZONE
2,480 SF
PLANES 1, 2, 3 and 5
8. Technical Difficulty

Limited Space with a lot of functionality

- The substation had a lot of equipment within a small footprint – compact design

- Considerations
  - Initial Installation
  - Maintenance
  - Fire protection/separation
  - Drive access
  - Future additions

- Network Design

- Space drove some major decisions
9. Site Activation

Public can be drawn in *because of the site features*

- “Celebrate” the rather than consider “negative”
- Public benefits were used to help meet this goal
- Each side of the project is unique
  - Alley: widening, lighting, art, UG utilities & landscaping
  - Denny Way: improved pedestrian experience, ramps & art
  - Minor Avenue: seat benches / off leash dog park, food trucks
  - John Street: green street features
  - Virginia Ave: view of the site & City Light neon signage
10. Many Teams

Diverse Project Teams

- Regular team meetings
- Exchange of drawing backgrounds
- All of the team members were experts in their fields
- Broadcasting versus over-bombardment
- Used MS Office Products standard for everyone
- Web based document management system
- Web based management action items, meeting notes, out of office schedule, upcoming milestones, collections of client review comments & equipment drawing submittal tracking
Design Team + ABB + MEPPI

Diverse Consultant Team with 30 areas of tech. expertise (~78 + 3 PM/PA)

- Substation (7)
- Distribution (4)
- Transmission (3)
- Electrical System Studies (4)
- Civil (4)
- Structural (3)
- Architectural (7)
- Mechanical (3)
- Electrical Building/Lighting (3)
- Intersection Design (2)
- Catering (2)
- Cathodic Protection (2)
- Public Involvement (3)
- Time Lapse Video (1)
- Hanger Door (2)

- Landscaping (3)
- Cost Estimating (2)
- Land Survey (4)
- Potholing (2)
- Geotechnical (2)
- Soil Thermal Analysis (2)
- Environmental (2)
- Acoustical (1)
- Electro-Magnetic-Fields (1)
- Land Appraisal (1)
- Water Deluge (3)
- Firewall (2)
- Traffic (2)
- Street Vacation (1)
- Restaurant Design (2)
SCL Team

Diverse Client Team – City of Seattle (49)

City Light (29)
- Project Team (9)
- Substation Support (6)
- Xmission Support (2)
- Distribution Support (3)
- Wiremen (2)
- Dispatch (3)
- Communications (2)
- Meter / Relay (2)

- Dept. of Transportation (3)
- Public Utilities (3)
- Planning & Develop (2)
- Environmental (2)
- Parks (1)
- Neighborhoods (1)
- Finance & Admin. Serv. (1)
- Information Technology (2)
- Civil/Mech Support (4)
- Art (1)
Evolving SCADA Design

- Integration of more IEDs was relatively easy using networking communications
- Added 2411s at each LCC
  - Location of IEDs precluded need of conduit fiber optic cable to make physical connections
    - Capacitor Bank IEDs
    - HPFF Plant
    - GIS Local Control Cabinets
    - ISL controllers
Automation Design Documentation

- Three GOOSE-based schemes:
  - Transformer Paralleling (LTC Master-Follower)
  - Subnet Control
  - ISL Control by ISL Supplier
- Functional specification describes:
  - Normal operation
  - Failure modes
  - Detailed GOOSE data per IED
- Documents were a guide for drafting the commissioning plan for each scheme
SCADA Data

- Digital I/O and metering data hardwired to IEDs
- Networked communications from IEDs to each RTU
SCADA Operation

- Both local manual control and HMI/EMS
SCADA Review

- Use of extensive SCADA network, MMS and GOOSE messaging may have cost a little more than initially thought but eliminated lots of hard wires and enabled the flexibility to make complicated changes that had less impact to the field (physical plant).
- Initial concept was very basic but migrated
  - 2411 in each LCC
  - Field installed SCADA fiberoptic LAN
  - GOOSE schemes (LTC control, subnet control & ISL)
SCL Challenges

- Urban environment increased initial project cost by over +50% - probably an extreme case
- Some internal political fall out
- Technical had to make possible urban design merit and public benefits and... have a functioning substation with 4 operating voltages in less than 400’ x 350’ area.
- No live exposed parts: No choice
- Give and take
Achievements

- Went through the political process of getting this project accepted – generally by all stakeholders
- Demonstrated that work with the public and City could reach a win-win outcome
- Positive feedback from design commission
- Achieved all technical aspects of the project with a state-of-the-art substation
- Hit used and useful target from 3 years out
Lessons Learned

- Urban designs tend to be significantly more expensive
- Diverse range of disciplines – be ready to get help
- Large project teams require more effort & structure
- Require teaming with local entities
- Avoid street vacation if at all possible
- You don’t know what you don’t know
- Challenging getting drawings from manufacturers well in advance of production start
- Find a management champion if you can
Lessons Learned

• We never had enough space, enough people or enough money
• Don’t multi-prime
• Perform up front studies and revisit after procurement (TRV and voltage stability)
• Design for the ultimate
• Re-confirm assumptions
• Carefully consider procurement
• Involve operations early and often
• Buy extended maintenance at bid time
• Be active within the community
Lessons Learned

• Set the qualifications bar higher
• Sometimes its better to be lucky but chance favors the prepared mind
• Can’t anticipate the worst that actually happens
• Use lessons learned
• Attend all factory tests and carefully review manufacturer drawings
• You need dispute resolution processes
Lessons Learned

• Plan and execute a detailed commissioning progress with like minded people
• Want your commissioning key persons to be part of the team
• Want a responsive design team that owns it
• Senior Management is a big deal
• You can survive with less sleep than you thought
• Find a coping mechanism
• 100+ engineers can still miss the obvious
• Phasing
More Lessons Learned

• Let the political process play out. Show no bias.
• Listen to what governing bodies say.
Actual View of Denny
GIS Fly Over
115kV Main GIS (4 Diameters, bkr-and-a-half)
Time Lapse – Camera 1
Time Lapse Camera 2
Drone Picture
Denny Substation
Successful Innovation & Teamwork

Questions?