PSPE Philadelphia Chapter
Outstanding Engineering Achievement Award Nomination Form 2022/2023

Project Information/Name of Project:

SEPTA Wayne Junction Static Frequency Converter Station Rehabilitation

Location of Project:

4720 N. 18th Street, Philadelphia PA 19141-1523

Description of Project, include specific details:

To increase power capacity and service reliability to its ridership, SEPTA selected STV Incorporated to provide comprehensive architectural and engineering services for the $66 million rehabilitation of the three existing 15 MVA static frequency converters and the installation of a fourth 15 MVA SFC unit at the Wayne Junction SFC Station. The total station capacity will be upgraded to 60 MVA.

Construction Cost: $66 million **Design Completion:** 10/15/2021 **Construction Completion:** 4/6/2028

Primary engineering disciplines represented by the project:

Traction power, electrical, communications, mechanical, plumbing, fire protection, architectural, civil, structural, geotechnical, environmental, cost estimating, scheduling, project management, quality assurance/control.

Organizations/Firms that contributed to the Project and are responsible for the achievement:

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Additional Information:

The SEPTA Wayne Junction Static Frequency Converter Station (SFC), located in North Philadelphia, is the sole source of 25 Hz power for SEPTA's Regional Rail System, serving over 26 million passenger trips in 2020. The engineering design and construction staging of this $66 million project is critical to maintain continuous power operation to the region's core transit system, serving the ninth largest metropolitan area in the United States by economic output.

The Southeastern Pennsylvania Transportation Authority (SEPTA) operates a system of commuter rail lines in the Philadelphia metropolitan area. The system, known as the Regional Rail Division (RRD), consists of various routes formerly owned by the Reading and Pennsylvania Railroads. The former Reading system is supplied with traction power from SEPTA's converter substation at Wayne Junction and the former Pennsylvania system is supplied by the Amtrak traction power system. Although the railway tracks of both systems are joined through the Center City Commuter Connection, the traction power networks for each are of different types and operate independently. The electrical systems are separated by phase breaks in the overhead power distribution system.

The majority of the RRD was electrified in the early 1900's and has operated safely and reliably ever since. Today, some of the original equipment is still in service, but due to equipment age, many electrical subsystems and components are at or near the end of their useful life and need to be replaced. One of these subsystems is the static frequency converter facility at the Wayne Junction power substation, located at 18th Street and Wagner Avenue in Philadelphia, PA 19141, USA.

The three existing SFCs are air-cooled, solid-state, cycloconverter-based modules that were built in the 1980s by ASEA, and are now in need of overhaul due to age. The SFCs convert 230 kV, 60 Hz, 3-phase power provided by PECO, the utility provider, to the 36/24/12 kV, 25 Hz, 1-phase power required for SEPTA's regional rail lines. This 25 Hz traction power system is inherited from the Reading Railroad in the early 1900's and requires specialized attention to all design details due to its unique characteristics.

To increase power capacity and service reliability to its ridership, SEPTA selected STV Incorporated to provide comprehensive architectural and engineering services for the $66 million rehabilitation of the three existing 15 MVA static frequency converters and the installation of a fourth 15 MVA SFC unit at the Wayne Junction SFC Station. The total station capacity will be upgraded to 60 MVA. STV's team included Sowinski Sullivan for architectural design, Matrix New World Engineering for civil engineering and permitting, American Geotech, Inc. for geotechnical services, and Promatech, Inc. for scheduling. STV led as prime contractor providing traction power, electrical, communications, mechanical, plumbing, fire protection, geotechnical, structural, and environmental engineering roles, including cost estimating, quality assurance oversight, and project management. STV was uniquely qualified to be selected for this project due to the team's previous experience on the original Wayne Junction SFC station, as well as their previous work on Amtrak's Sunnyside, Richmond, and Metuchen SFC projects. Brandon Swartley was chosen as project manager based on his previous work leading the conceptual design studies, engineering, procurement, and commissioning activities for the Amtrak 180 MW SFC Station in the late 1990's, the largest frequency converter station in the world at that time. He also performed engineering studies and design for the Metuchen 60 MW SFC Station in 2018. He presently serves as the Project Manager and Lead Engineer with STV for the Amtrak Sunnyside Yard SFC Station and Amtrak Jericho Park SFC Station rehabilitation projects.

STV's role in the Wayne Junction SFC Project was to meet the challenge of selecting the required SFC technologies that meet the project design criteria, while integrating this technology into the existing facility infrastructure with minimal impact, and keeping the station operational to continuously serve the Delaware Valley Region. The team was also tasked with rehabilitating the facility, expanding it for the new SFC equipment, and upgrading all supporting auxiliary systems.

The STV Team completed the the final design for the WJSFC project in 2021 and will continue to support this project through a 5-year construction and commissioning period. The team consists of project management and multidiscipline engineering design staff, with over fifty engineers, designers, drafters, and support personnel from five firms. The project started with a conditions assessment of the existing facilities and an evaluation of the latest SFC technologies. An alternatives and cost-benefit analysis summarized the team's recommendations. Upon SEPTA's approval of recommendations for facility upgrades and the method for SFC replacement, the project proceeded forward with site surveys, soil borings, geotechnical analysis, and environmental samplings. SFC technical specifications and design requirements were prepared to ensure the new SFC technology would integrate

and operate in parallel with the existing equipment during a staged installation approach. At the 60% design stage, SEPTA selected an SFC equipment vendor, Siemens. The project team then integrated the Siemens SFC system requirements into the balance-of-plant design and reviewed vendor submittals at their 30%, 60%, 90%, and 100% design stages. Siemens design included over 2000 drawings and 100 specification, calculations, and reports. Procurement of the SFC equipment paralleled STV's final design efforts. The new SFC #4 unit required an addition to the existing building, involving zoning permit and building permit applications. Design deliverables by STV and its subcontractors included 350 drawings, 138 specifications, 16 reports, and 13 sets of calculations.

Final procurement contract documents were issued in 2021 for general, electrical, and mechanical contractor bids in accordance with Pennsylvania's Separations Act. The zoning and building permits have now been approved, the construction contractors awarded, trade permits are being issued, and construction has begun. The design team is presently supporting construction phase services by reviewing contractor equipment submittals, interpreting design requirements, and assisting with installation and shop drawings. The engineering team will witness factory acceptance testing and support field testing and commissioning during construction.

Engineering Challenges and Innovative Solutions

The project presented unique challenges in that all design decisions were based on the operational requirement to keep a minimum of two SFC units in operation at all times to maintain power to the railroad's daily traction power demand. Three new SFCs will replace three existing SFCs, and one new SFC will be installed in a new building addition. Construction sequencing is a primary focus that permeates all design aspects, including the demolition of existing equipment, installation of new equipment, systems integration, and commissioning of each unit one-at-a-time.

Due to unique technical requirements, an industry questionnaire and evaluation was conducted by STV, using 26 major technical categories and 133 questions. There was determined to be only three SFC vendors that supply SFC technology compatible with the requirements of this project. However, none could confidently offer to refurbish the existing SFC power block electronic equipment, power transformers, control systems, protection systems, or cooling systems, largely for integration reasons. Therefore, one of the original scope items of this project, which was to "refurbish or replace as necessary" the existing converter systems, was fulfilled by replacing, not refurbishing, these units. The newer technologies used water-cooled heat exchanger systems and had various vendor-specific options for input and output power transformers. After the team evaluated available technologies and equipment layout options, Siemens was selected to provide a multi-modular converter technology to replace the existing cycloconverters.

SEPTA's traction power system is unique. It is the only system in the world to operate at 25 Hz, single-phase, supplied with 12 kV trolley voltage and 24 kV feeder voltage from two-winding transformers, and boosted throughout the system using autotransformers. Combine this with a highly fluctuating traction power load profile, vehicle and converter induced harmonics, special SFC installation and operating requirements, and interfacing 60 Hz and 25 Hz power systems at the same station, the STV team needed to pay close attention to all engineering, operational, and maintenance aspects when selecting equipment ratings and integrating the system. Attention to detail permeated the design of the mechanical, electrical, fire protection, plumbing, communications, architectural, civil, structural, geotechnical, and environmental aspects and supporting systems.

As if managing this unique design rehabilitation project was not enough, the design team also interfaced and integrated the Wayne Junction project with other ongoing major SEPTA projects that impacted design requirements and the project schedule, including the upgrades in the connecting 25 Hz traction power substation, the replacement of 230 kV, 60 Hz supply line protection schemes, upgrades to fire protection control systems, and the design and integration of two new 1-mile 25 Hz, 13.2 kV distribution lines from the new Midvale Combined Heat and Power Plant. The STV team was selected to design and implement the 230 kV relay replacements and the 13.2 kV distribution line while working on the Wayne Junction project. Mr. Swartley guided his project team through the technical challenges presented by these evolving criteria, integrating them with the master plan, while keeping the project on schedule and within budget.

Importance of the Engineering Profession to Society

Many times, an owner can select to have equipment nearing its end-of-life replaced by similar equipment. This is often accomplished by hiring a contractor to procure and install the equipment. However, when equipment becomes obsolete, there are limited replacement options, and maintaining operation of a system is critical, an engineering team must be hired to evaluate the existing system, design a replacement system, prepare

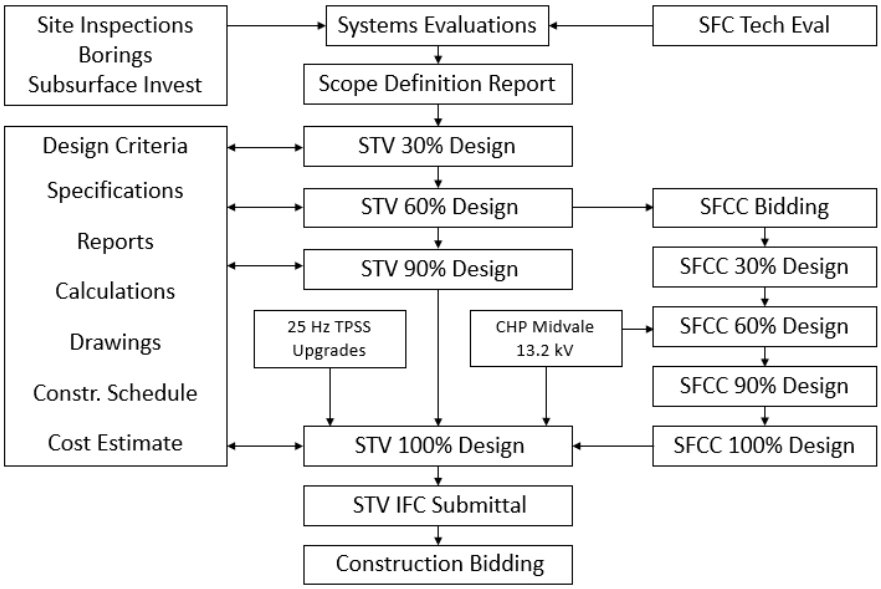
procurement documents, and provide project management to execute, install, and commission system. This project demonstrates how a project management and engineering team can successfully work together to provide society the tangible benefit of a reliable transportation system.

Benefit to the Delaware Valley Region

The clear benefit of this project to the Delaware Valley Region is maintaining the operation of a Regional Rail system that provides transportation for 26 million passenger trips annually.

The Existing Wayne Junction SFC Station to be Rehabilitated

Design Process



Design Summary

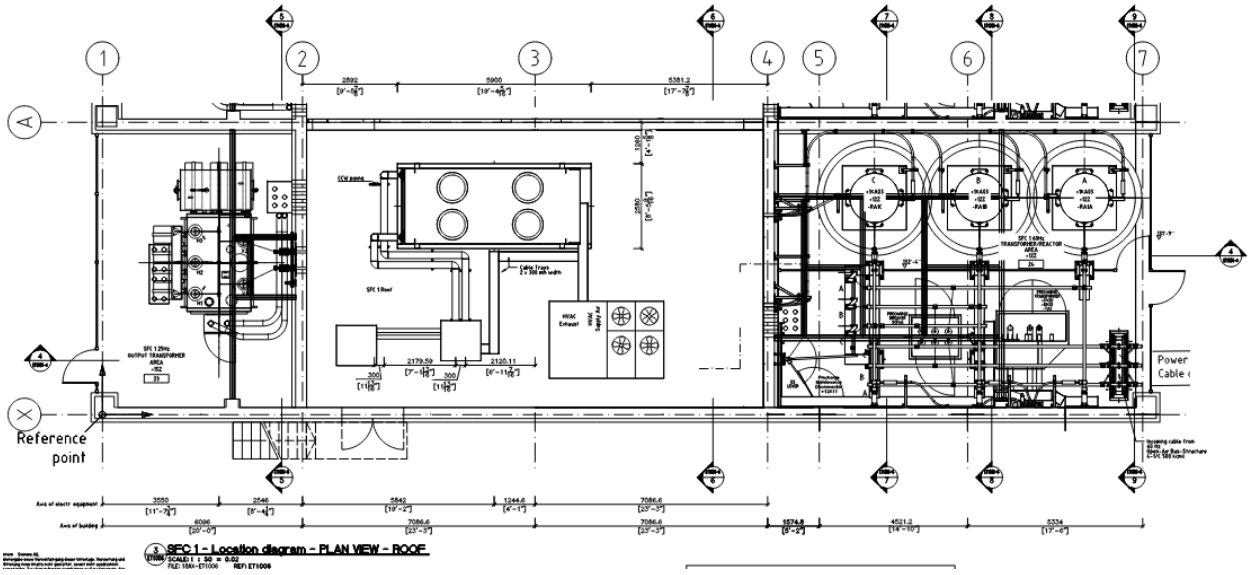
- Replace three SFCs and add a fourth SFC, each rated 15 MVA continuous with overload capability. New SFCs shall operate both independently and in parallel under either manual or automatic load sharing control.
- Spare 13.2 kV and 480 V breakers in 230 kV Control Building power the new SFC #4.
- 60 Hz filter equipment to be removed. Open-air substation equipment to be re-used/replaced.
- New duct banks constructed from 230 kV Control Building to 60 Hz Yard and SFC Building, to 25 Hz Yard, and to 25 Hz TPSS for SFC #4. All other duct banks re-used.
- All cable trays removed from SFC basements and replaced with new tray system.
- 60 Hz SFC transformers replaced with air-core reactors and pre-charging equipment.
- New building addition for SFC #4. Existing building HVAC, plumbing, fire detection and suppression, communications, and electrical systems updated.
- 25 Hz SFC transformer replaced with new oil-filled transformers. New oil-containment pits.
- 25 Hz filter equipment to be removed. Open-air substation equipment to be replaced.
- New SFC disconnects, relays, disconnect switch aux contacts in 25 Hz TPSS. CTs re-wired.
- New key interlock systems for breakers, disconnects, ground switches, and SFC rooms.

Design and Construction Summary by Discipline

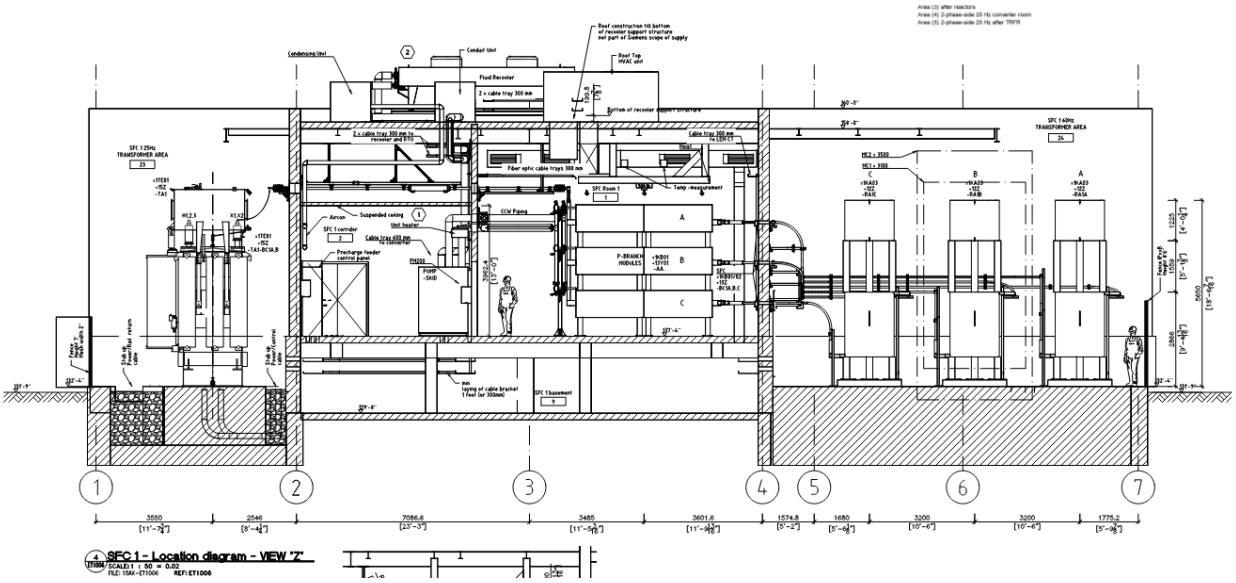
- **Traction power** – interface with SFC control system, modify 13.2 kV protection scheme, new duct banks, replace open-air substations, replace basement cable trays, new 25 Hz relays, new disconnect in 25 Hz TPSS yard, interface with existing 60 Hz and 25 Hz traction power systems
- **Electrical** – replace 125 V dc battery system, replace lighting with LED-type, supply Siemens with 480 V ac and 125 V dc power feeders
- **Communications** – new 24-strand fiber between 25 Hz TPSS & SFC Building, replace RTU, new intrusion alarm system, new GPS antenna, new TSP to 230 kV Control Building 480 V and 13.2 kV switchgear, new Multifunction Gateway
- **Architectural** – new SFC #4 bldg, new partition walls, repair facade, new fall protection, remove vent stacks, seal unused floor hatches, infill floor under old SFCs, add interference screening around SFC #4 Building
- **Mechanical** – replace HVAC system and ductwork to match new heat removal requirements, new digital controls
- **Plumbing** –new safety shower, eye/face wash, water heater, mixing valve, new roof drains and rainwater piping
- **Fire Protection** – replace Pyrotronic suppression/fire alarm control panels in SFC Building and 230 kV Control Building, replace Halon with Clean Agent FM-200 system and seal rooms in SFC Building areas, remove 60 Hz deluge system, replace 25 Hz deluge system
- **Civil/Survey** – topographical surveys of monuments tied to coordinate system grading, composite utility plans, storm sewer/drainage work, grading, duct bank profiles, roadways within project area, erosion and sediment plan, fencing, manual/motor-operated sliding gates
- **Structural** – new micropiles and foundations for STV/Siemens power equipment and SFC #4 building, new/modified roofing and framing system for SFC buildings, new/modified 25 Hz oil retention pits, modify existing building walls/openings, new structural steel supports for substation equipment, new hoist system in SFC Rooms
- **Geophysical** – subsurface investigations, ground resistivity measurements, contamination disposal recommendations
- **Geotechnical** – chemical testing, boring logs, geoprobes, laboratory tests, evaluation of geophysical investigations for foundation design, micropile design, groundwater control
- **Environmental** – contaminated soil, lead paint, asbestos abatement, universal waste
- **Utility Coordination/Regulatory** – utility mapping, draft permit applications

Overall Site Plan with New Building Addition and New Equipment

Plan View of New SFC #1



Elevation View of New SFC #1



Wayne Junction New 230 kV Relay Panels