HVAC SYSTEMS ASSESSMENT

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Origin and Purpose of This Document.

The Construction Services Group Unit of ESD112, a statewide K12 Facilities planning, design, evaluation, project and Program management resource for school districts, was contracted by the Chimacum School District in August of 2015 to conduct a formal assessment of existing heating, ventilating, & air conditioning systems (HVAC) and direct digital controls (DDC) serving district facilities.

This effort, conducted by Licensed Mechanical Engineer Geert Aerts, *CSG Existing Buildings Commissioning Manager*, (see resume attached) in concert with *CSD Facilities Manager* Henry Florshutz, is intended to inform district decision-makers about the true & verified nature, vintage, suitability, condition and viability-for-continued use of HVAC systems and controls in all school occupancies. The district administrative offices and transportation center were not within the scope of this analysis.

This CSG work product is intended to inform decisions, strategies, and budgetary planning for facility maintenance, renovation, renewal, or replacement of systems and controls maintenance & operations (M&O) as well as capital construction planning.

Also contributing to this report, as the key provider of budgetary information for cost estimating, was Pro Cost, LLC., a highly experienced construction cost estimating firm with whom CSG has estimated scores of school construction project costs.

Important Linkage to the Companion Electrical Infrastructure Assessment

Since the CSD facilities are "all electric", with no other energy source available, and much of the serving electrical infrastructure is (with some exceptions), similar to the HVAC infrastructure, with aged, dated equipment, and, in many areas, capacity and/or current code compliance is lacking, it will not be possible to execute any significant HVAC improvements without first addressing electrical issues.

The exception to this general statement RE electrical infrastructure issues, is CCP, which is served by PUD as a "secondary service" customer, with PUD-owned and maintained transformers, site feeders, and district-maintained switchgear. Any proposed modifications to CCP, the nature and scope of which are currently not known, will trigger an appropriate electrical infrastructure assessment at that site.

With CSD utilizing a service-to-site utility model called "primary service" (a very unusual utility relationship for public schools) it must be understood that there are capacity and configuration constraints imposed on the reconfiguration of mechanical systems by the nature, age and condition of the electrical system, and restraints to modification of that serving electrical system imposed by Washington Labor & Industries in K12 occupancies. (More on this in the accompanying electrical infrastructure assessment)

Therefore, construction estimates for HVAC electrical connections, which the estimator made with the assumption that removal-replacement of similar sized units would not impact electrical supply, are not fully accurate as rendered by Pro Cost, but which have been adjusted in this document summary section to reflect full loading for soft costs in addition to contractor bid cost expectations.

Executive Summary of Findings:

Equipment uptime and student/teacher comfort:

The up-time (availability to operate) of HVAC equipment and classroom comfort at Chimacum School District is above average for school districts of all sizes in Washington. Classrooms were at comfortable temperature conditions at the time of the facility condition assessment.

The exception is the Elementary School and Library, where lack of a DDC system prevents monitoring of temperatures, and where historic noise and equipment age prevents continuous functioning of the equipment. We attribute this positive finding, in light of the persistent challenges, to the diligence of the district in the identification of issues, engagement of corrective actions and resources, and persistence in recovering from what was, until recently with the change of facilities management, an apparent long history of deferred maintenance and renewal.

> The maintenance department provided to this assessor an excellent list of all the mechanical equipment in the District. This list is exceptional and has never been available at other School Districts when conducting assessments, thus demonstrating a high level of issues awareness and persistence addressing them.

Deferred maintenance:

The District and contractors are performing first-rate maintenance and have almost eliminated a large backlog of deferred maintenance, with proper prioritization of work within available funding. For example, all fire dampers have for the first time been located, repaired and fully integrated with the fire alarm system, as required by code. The district also engaged a licensed fire alarm evaluator to conduct full-scale confidence testing of the fire systems, with all corrective measures performed. It is the opinion of this assessor that in six months most of the deferred maintenance may be caught up. This is not to say that new or recurring issues will not be challenging. They will, given the age and general condition of several major system elements.

Replacement or continuing maintenance of HVAC equipment:

The majority of HVAC systems at Chimacum School District were manufactured in 1979, 1981, 1991, 1998 and 2000. In the event of a modernization, since such equipment is expected to last 25-30 years when new, all these vintages of equipment would be likely candidates for replacement, standardization, and proper integration. If not replaced during a modernization, these systems are of sufficient quality that they can be maintained for the next 5 and possibly even 10 years.

With the exception of Elementary and Library equipment. Life-extension through continued intensive maintenance would consist of replacing components as they fail, such as fan motors, compressors, water leaks, DDC system controllers, circuit boards and electric and pneumatic components. Some equipment at the High School was manufactured in 2006, 2013 and 2014 and would not be replaced during a modernization.

Pro-active maintenance of water heaters:

The majority of the water heaters at Chimacum were manufactured from 1979 to 1999 and the District has recently repaired a large number of deferred water leaks at and near water heaters of all these vintages. The condition of the tanks themselves is difficult to determine, but if a tank leaks or a leaking fitting cannot be repaired then the leaking water heater would have to be replaced in total. Many of these water heaters are oversized for the use of hot water by students today; the District desires to recalculate the actual water usage. Pro-actively replacing these water heaters once a calculation has been performed would provide sufficient time to order the correct equipment, would lower first cost and energy cost if a smaller water heater could be used. The circulation pump could possibly also be downsized if calculations or flow balancing shows it to be oversized.

Connections to the tank and piping above the tank are prone to corrosion, and numerous leaks have occurred in the past that have been mostly repaired. The incoming cold water pipes and cold water distribution pipes and fittings do not typically leak. The leaks at the tank connections are in some part due to water running down the water heater from leaks in piping above the water heaters. The leaks in the piping above the tanks may be due wholly or in part to corrosive dissolved gasses that come out of solution when the water is heated, resulting in internal corrosion of the piping above the water heaters. The water supply company could be contacted to discover if the local water is corrosive and if there are any easy means of mitigating this. When water is somewhat corrosive as it appears to be at Chimacum, then the interior of piping becomes more prone to erosion-corrosion internally. If leaks continue to occur primarily at bends on piping, then it is recommended that future leaks be investigated by splitting open the pipe with a band saw and examining the pipe internally. If erosion-corrosion is occurring, then the circulation pump should be downsized.

Digital (DDC) control system:

Recent energy grant work has resulted in good DDC (direct digital controls) platforms for the Primary, Middle and High Schools and Multipurpose building. Approximately 10% of the programming and graphics were not completed and the District is aware of these deficiencies and is asking the controls companies to finish the programming and graphics. The control companies also need to furnish the District with written sequences of operation and explanations of current parameters and acceptable ranges of those parameters. One example in particular is the sequence for optimal start and how the District can configure this to its needs. The District has expressed a preference for a single control platform. The Elementary School, library and maintenance buildings have no DDC (only pneumatic controls) and the multipurpose building is DDC over pneumatic.

Energy efficiency:

Energy efficiency at Chimacum SD is likely better than average for an all-electric school district based on the substantial use of heat pumps (vs. electric resistance heat) and the proper scheduling of the HVAC equipment to turn off after the end of the school day. The average Energy Use Index (EUI) of schools in Washington State is approximately 60 kBtu and $1 per square foot per year. Schools with electric resistance or oil heating could cost somewhat more. Comparison of Chimacum School District energy use to this benchmark would show how well Chimacum SD is controlling its energy use.

If compared to Sequim SD, it would be good to be cognizant that Sequim has the best energy management of the 17 school Districts upon which CSG has performed energy audits. Two factors that account for low energy use at Sequim SD are: 1) a previous facilities director very interested in energy savings, 2) very tight scheduling of occupied HVAC times and 3) an optimal start program that turns on equipment only as soon as needed.

<u>**Energy Grant work:**</u>

The 2013/2014 McKinstry and Erickson-McGovern energy grant work appears to be functioning for the most part. A few loose ends were noted that still need to be finished. The grant work was not reviewed separately and in detail by this assessor for its ability to meet occupant comfort or energy goals. If Chimacum SD desires, CSG can perform such an assessment.

One interesting issue is that when the auditorium was switched by McKinstry from a steam boiler to electric resistance heaters in the supply ducts to the auditorium seating area, no provisions were made to provide replacement heat for the three dressing rooms steam radiators or the two stage steam radiators. The stage may receive sufficient heat from the auditorium, but the dressing rooms cannot be warm in winter since they are located on an exterior wall. Freezing of plumbing in the dressing room bathrooms that are on an exterior wall could be a concern in a very cold weather.

The DDC controls that were upgraded during the energy grant work still need some minor finishing work. The make-up air unit for the paint booth exhaust fan is not on the control graphics. Some graphics details, such as directions of arrows, are not correct. The readouts from some temperature sensors appear incorrect - the inputs may be incorrectly programmed in the controls. Finishing the controls work, including 100% correct graphics, should be performed at no charge to the District, as part of the energy grant work.

Further explanation should be provided to the District on the Optimal Start programming that brings the rooms to the desired temperature at the beginning of occupied time. This programming is unique between each control system. Also, access should be provided to the District to the input parameters for the optimal start programming so that the District can fine-tune the start time.

School-by-School Condition of HVAC:

Chimacum Creek Primary School (new in 2001):

The 2000 split-system heat pumps with inside air handlers manufactured by Trane are in fair shape. Per the McKinstry maintenance technician they are approximately the same condition internally as the High School heat pumps. They appear in better shape externally because the external metal is not rusted, however, there is some mildew/moss discoloration. The black foam insulation of the refrigerant lines outside of the building are in poor condition. The exhaust fans are in good shape because they are inside the building in the attic. The DDC controls are in good condition.

Because the air barrier in the attic is leaking, this school becomes cold at night in the winter. As a result, the classroom heat pumps must be turned on earlier than desired to heat the classrooms by the start of class. Also as a result of the poor air sealing of this school, the night temperature setting cannot be lowered as much as other schools. The air barrier at this school consists of sheets of white, flexible fabric installed under batts of insulation under the roof deck. Outside air is designed to remain between the batts and roof deck as it travels been eave and ridge vents.

This is a design that is impossible to air seal 100%, however, with excellent workmanship it can be made to work reasonably well. The workmanship at CCP was not good, with large gaps that allow cold air into the attic area. There is no insulation between the attic and the classrooms. In addition, the air barrier staples have pulled loose in many places, allowing air to enter and batts to fall down. At several other schools with this type of air barrier problem, sprinkler piping has frozen in winter; with sufficient air barrier leaks the temperature of the attic essentially becomes the same temperature as outdoors. If cold air is entering the school through relief ducts, check for backdraft dampers on relief louvers at the building envelope. If none exist and air leakage is significant, barometric or powered dampers could be added.

Elementary School (built 1948, HVAC equipment 1981):

The 1981 through-wall unit ventilators manufactured by Herman Nelson are too noisy for most teachers. They have likely been too noisy from the time this equipment was installed during a modernization in 1981. One classroom recently switched from storage to teaching has a unit that was used for parts, since new parts are difficult to obtain. When the unit ventilators are not running, they are not providing outside air, thus classrooms may or may not remain below acceptable CO2 levels. Acceptable CO2 levels in Washington schools are 700 ppm above ambient outside levels; thus, approximately 400 ppm outside + 700 ppm = 1100 ppm. Quieter through-wall ventilators can reportedly be obtained, but they are larger and therefore may not fit the existing wall space, and they are reportedly twice as expensive as normal through-wall ventilators. Retrofitting the HVAC in these classrooms must take into account the outside air requirement, so if the through-wall equipment is abandoned, usually rooftop or mezzanine equipment is used, with ductwork above the classroom ceilings. The pneumatic control system is functioning.

Library (built 1968, HVAC equipment 1981):

The 1981 through-wall unit ventilators manufactured by Herman Nelson are typically off unless needed for heat. One of the through-wall unit ventilators is not working and parts are difficult to obtain. Library staff training is needed so that library staff can understand how to turn on and off the unit ventilators. Because the occupancy per square foot is not as high in the library as in classrooms, the CO2 levels will not rise as high when the unit ventilators are off. Retrofitting the HVAC in the library must take into account the outside air requirement, so if the through-wall equipment is abandoned, usually rooftop or mezzanine equipment is used, with ductwork above the classroom ceilings. The pneumatic control system is functioning.

Middle School (built 1959, HVAC equipment 1999):

The 1991 fan-coil units are very sturdy, quality Temtrol units that are in good shape. The fan bearings have lubrication ports. There are some boiler loop water leaks at connections to the fan-coil units.The 1991 electric-resistance central boiler is in good shape. The two 1991 building circulation pumps are in good shape. The DDC controls are in good condition. The school is split between the two control vendors (ATS and CCI) and their different control platforms (Alerton and unknown).

High School (built 1980, HVAC equipment 1981, 1999, 2006, 2013, 2014):

The 1998 single-package rooftop heat pumps with economizers manufactured by Carrier are in fair shape. The external appearance of the heat pumps is likely worse than their internal appearance because rusting of the exterior of the cabinets is beginning to occur. The 6 single-package rooftop heat pumps with economizers, manufactured by Aaon, installed as part of energy grant work in 2014 are in excellent shape.

The CO2 sensor for the commons has previously had its wires cut to remove it from the controls. It is not known if miscalibration or poor programming contributed to the disconnection. Some control work from the energy grant was never completed (such as programming/graphics for paint booth MAU), graphics. The rooftop fans are in variable shape with some newer stainless steel fans in like-new shape, others in fair shape and functioning, and some with broken belts. Some are on the DDC system and some are not and the District is in the process of making an inventory. During a modernization a decision could be made whether or not to place other fans on the DDC system.

In the auditorium in 2013 the steam boiler was taken out and two electric resistance heaters were installed for the two supply air ducts running from the 1981 air handler (with economizer) serving the auditorium seating area. This air handler has been significantly altered over the years and may have at one time used evaporative cooling. In 2013 the damper actuators were replaced. The old steam radiators on either side of the stage and 3 in the dressing rooms remain but are not functional. Some provisions for heating these space for occupants during cold weather, or preventing freezing of plumbing fixtures, may be necessary. Henry reports the back wall of the dressing rooms may be extended during a modernization, so this would be the time to design new HVAC equipment.

New heat recovery units heat pumps were installed for the locker rooms in 2006. These units are in good condition. A new multizone rooftop unit was installed in 2013 to serve 8 classrooms. This unit does not provide cooling and could only do so if external, rooftop condensing units were to be installed. This is in excellent condition. The 1981 gym air handler damper actuators were replaced under energy grant work in 2013. The DDC controls are in good condition.

Multipurpose Building (built 1952, HVAC equipment 1979):

The 1979 fan-coil units are in good shape since they are very sturdy, maintainable units with few moving parts and no electronics. The pneumatic control system is functioning and monitored by DDC that is displayed on the control computer in the maintenance building.

Maintenance Building:

The 1981 electric ceiling heaters are functioning. No control system (neither pneumatic nor DDC). If the building is modernized these would likely be replaced.

Transportation Facility:

Expected to be replaced under existing levy funding.

List of HVAC equipment needed for Chimacum School District modernization for pricing by ProCost:

Replace 22-ea. 1999-vintage, single-package heat pumps like for like:

- 1 ea. 2.5-ton, 11 ea. 4-ton, 6 ea. 5-ton, 2-ea. 6-ton, 2-ea. 13-ton
- All heat pumps have 100% economizers with mixing dampers (outside air and return air), supply fan, and 2" filter rack. Typical current model number is Carrier 50TJQ004
- 460-volt, 3-phase
- No auxiliary electric resistance heat is needed since this is in the ductwork.
- Include marine option for coil coating and paint quality
- Include rooftop installation on top of two, 1-story, flat-roofed buildings
- No electrical or control wiring or condensate piping appears to be needed
- Furnish each heat pump with a new BACnet DDC controller to replace the current DDC controller at each heat pump
- Can't estimate this by square footage since these are spread across the two side-by-side Middle and High Schools and these schools also contain a mixture of 2006, 2013 and 2014 equipment that won't be replaced

Replace 21-ea. 1981-vintage fan coil units like for like:

- 1,000 cfm, hot water coil only, 0.75 HP supply fan and no return fan, with mixing dampers (outside air and return air), and 2" filter rack. Typical current part number is Temtrol DHT-4S
- 460-volt, 3-phase
- Include installation in mechanical mezzanine but no ducting, piping, electrical or control wiring since the fan coils are already located in the mezzanine and already ducted and plumbed to a two-pipe boiler-fed hydronic loop and controlled by DDC. Include some labor and materials to transition the ductwork, as well as route existing piping to the new units and replace pipe connections at the air handlers that are galvanized steel rather than copper.
- Furnish each fan coil with a new BACnet DDC controller to replace the current TUX card at each fan coil
- 2" filter rack

Replace 32-ea. 1991 and 1999-vintage rooftop exhaust fans like for like:

- 500 cfm (average) commercial quality stainless steel hood, axial motor (no belt) (include installation)
- no electrical needed, single phase 120-volt
- District to decide later after reviewing all fans for a DDC connection or end-switch whether or not some fans will need control wiring run from the nearest heat pump and a current transformer installed at the fan
- on 1-story, flat roof

Replace 11-ea. 1979 through 1999-vintage water heaters after proper sizing calculations:

- 100 gallon size (average), electric, commercial quality with expansion tanks (include installation), 480-volt, 3 phase
- no plumbing or electrical needed

New heat pumps for the 12,000 sq ft Multipurpose Building to replace existing electric resistance fan coils that are currently using DDC over pneumatic controls. Possible basis of design is United CoolAir C-Series. Very roughly 2-ea. 10 ton and 2-ea. 7.5 ton.

Heat pumps could be installed in the mechanical mezzanine above the 1st floor and ducted through the side walls using existing louvers for outside air and new louvers for condenser exhaust. 50% existing ductwork could be reused and 50% new ductwork would be needed. Include 100% economizer, outside air and return air dampers, 2" filters. 460-volt, 3 phase. No electrical. New DDC control sensors would be installed on the equipment itself (if not already installed) and a new BACnet DDC controller would be installed for each of the 4 heat pumps.

There will be substantial engineering, scheduling, permitting, bidding & procurement work (cost of which is included in the estimates) necessary to execute the identified scope within the time slots available. There are also lead times to be addressed for larger component parts and equipment that will affect schedules; availability will vary by season and construction general activity levels.

Another factor that will affect timing and bundling of the work here in Chimacum will be, if present construction market conditions continue as expected for the next several years, and the availability of workers, particularly during the summer school construction season. Large construction projects all along the I-5 corridor are creating demand well in excess of native local resources. This may result in doing work over an extended period with less staff, despite inefficiencies.

Once the Engineering begins there will undoubtedly surface some supplemental scopes of work required to make room for installation of ducts and components and similar impacts not fully known until deeper discovery and design begin. The estimated costs in this analysis include a 10% construction contingency that should be sufficient to fund most such "known unknowns".

On the next page are the elements of scope and cost to complete the MECHANICAL INFRASTRUCTURE MASTER PLAN program. These planning estimates are made with the assumption that there are no substantial modifications to the building configurations, except where noted.

SCOPE	ESTIMATED COST	RECOMMENDATIONS
1. <u>Global HVAC system upgrades and replacements in all main campus occupancies.</u> Includes heat pumps, chiller all related installation components and building modifications driven by these elements of work. Excludes controls (see Scope 2) Includes engineering, permits, L&I fees, project management, contractor labor & materials, and 10% contingency.	**$ 2,102,500*** *This estimate does not include essential electrical system upgrades that must be undertaken to support the extensive mechanical modernization, by code.	We recommend that phasing and bundling of the electrical and mechanical work elements be carefully phase coordinated once full program funding is known to be available. If full program funding is not available, or available only in annual releases, then all electrical modernization should proceed mechanical modernization.
2. <u>Global HVAC Controls System upgrades.</u> Includes all elements of work, controllers, software, and related components and labor to install a new controls system for the new global HVAC infrastructure above. This work must be fully coordinated with unit replacement scope above to assure compatibility and interoperability. Includes engineering, permits, L&I fees, project management, contractor labor & materials, and 10% contingency.	**$645,250***	Scope 2 is not executable without having performed Scope 1, so as to assure that the controls system fully addresses all unit features and capabilities within reach and full management capacity of a single unified operating controls system. All HVAC component purchase for which control is required shall be acquired under a unified specification to assure full DDC functionality.