The Design Challenges: Worksheets

Your Project Description & Anticipated Energy Demand

Briefly describe your building project, use, location, etc.:

Bethke Elementary School is a prototype elementary school for the Poudre School District. It will service grades K-5 in a core learning format. The school is located in a new residential development outside the town of Timnath, CO.

General

Building Size:	62691	*Sq. Ft.*
Property Size:		*Sq. Ft.*
Number of Parking Stalls:	100	

Electrical

Annual Electrical Usage:	378	*1000 x kWh*
Peak Electrical Demand:	372	*kW*

Heating

Peak Heating Demand:	1,300,000	*BTU/hr*
Peak Winter Day Demand:	15,000,000	*BTUs*
Average Winter Heat Demand:	5,000,000	*BTUs*

Cooling

Peak Cooling Demand:	66	*Tons (BTU/hr)*
Average Summer Day:	320	*Tons-hrs/day*

Hot Water

Annual DHW Demand:	70,000	*Gallons*
Swimming Pool Size:	N/A	*Gallons*

Your Project FLEX Energy Default Calculation Results

Ground-source Heat-Pump

Vertical Bore Field Area: 10,500 sq feet (102.5’ x 102.5’)

Peak Electrical Demand: 26.7 kW

Ice Storage Requirements: XXX Tons

7,500 Gallons, 1013 cu-ft, 6’ x 169 sq. ft. (x 4/pi) 14.7’ x 14.7’

Latent Heat Storage for 137,000 BTU

7,500 Gallons, --- 6’ x 14.7’ x 14.7’

PV:

Needed for 6kwh/sqft * 60,000 = 360,000 kWhr (178KWp) 9,500 sq, ft. =100’x100’

Wood Biomass:

Peak systems 2,500,000 BTU/hr, Boiler Area (look-up table based on real examples): 2,500 sq. ft.

Fuel needs 690 ton/year, peak month: 400tons, 1.4 trucks per week.

Storage 250 tons, area @ 6’ deep: 3,100 sq feet - 55.6’ x 55.6’

Electric Vehicles:

225 kW peak demand for 45 vehicles.

Design Challenge: Adding A Centralized Biomass Boiler

☐ The building design includes a centralized biomass boiler that provides more than 50% of the annual heating demand.

Show:

☑ The 2.5 MMBTU boiler that typically requires a 2,000 sq. ft. of mechanical space (either attached to your building or a separate building).

☑ The 150 tons wood chip storage taking 1,800 sq. ft.

☑ The access route for a 56' deliver truck with a turning radius of 31'. You will need to accept deliveries during normal business hours to keep deliver costs low.

This sheet contains the above designations: C24 - FlexEnergy Plan

Tell:

Describe how biomass boiler system interface with your building's HVAC system:

The building heating system is presently a hydronic system. Biomass boiler(s) could be connected to this existing system with relative ease. The proposed location for the biomass boiler system would be south of the existing boiler room, requiring the cooling tower to be relocated to accommodate the added mechanical room space and the biomass storage space. The existing hydronic system controls would be expanded to accommodate the biomass boilers. No changes to pump controls or terminal heating unit controls would be needed.

Discuss other issues related to retrofitting a Centralized Biomass Boiler.

Soot in the air may blow across the playground area.

Design Challenge: Adding District Energy Connection

☐ The design includes Electric Vehicle charging stations for more than 50% of the parking spaces.

Show:

☑ The connecting point to your building where district energy piped (hot and chilled water) will enter your building.

This sheet contains the above designations: C24 - FlexEnergy Plan

Tell:

Describe how hot and chilled water from the district energy system interface with your building's HVAC system:

This option is not a possibility for this site. The school sits in a suburban residential development. District energy plants are only feasible in locations where multiple buildings can be served, such as urban areas or campus settings.

If thermal energy is delivered to your building from the largest adjacent street, how far will the pipe need to travel to get to your designated connecting point?

The connection would be similar to that of the other utilities, about 600'-0".

Design Challenge: Add Electric Vehicle Friendly Parking Lot

☐ The design includes Electric Vehicle charging stations for more than 50% of the parking spaces.

Show:

☑ The location underground wiring from 50% of your 45 stalls to your site transformers, and the location of an additional transformer capable of providing 225 kW of additional service.

This sheet contains the above designations: C24 - FlexEnergy Plan

Tell:

If 50% of your parking lot of 90 is filled with electric vehicles need to be charged in 6 hours with enough energy for a 10 mile drive, You will need to provide an additional 225 kW of electrical service to your project. How will you meet this need?

Bethke ES presently is provided with a 600 ampere 480Y/277V, 3Ø, 4 W service from Xcel Energy with a 225KVA 480V, 3Ø primary – 208Y/120V, 3Ø, 4W secondary dry-type transformer for building systems. The calculated load, based on the National Electrical Code (NEC) requirements of the 480Y/277V service is 510 amperes; the NEC calculated load for the 208Y/120V distribution board is 480 amperes or 172.9KVA. We acknowledge the metered load will be less than the calculated however it does not appear there will be adequate capacity to meet the vehicle charging power requirements. Adding capacity would require replacing the main distribution board (MDP) with a 800 or 1000 amp switchboard, upgrading the service lateral to the rating of the new MDP and replacing the existing Xcel Energy pad mounted transformer sized to support the new load. A new 208Y/120V, 3Ø, 4W trans former and distribution board would be required for power distribution to the vehicle charging equipment. There is no available space in the existing electrical room for the new transformer and panelboard; these units could be located in a fenced enclosure outside the building. The most practical location appears to be on the south side of the mechanical equipment yard.

How will you install charging stations for at least 45 parking stalls?

On a future project it would be a good idea to route conduits to hand holes in the parking lot islands for future extension of power for electric car charging stations. The future designs could address providing a panelboard in the electrical room or mechanical room to supply the charging stations. From the information we are finding many of the electric car charging systems require a 208V/230V, 1 phase circuit. This requires 2 circuit breaker spaces for each charging station, providing for 45 charging stations would require 90 circuits. Providing the in-ground conduit is best accomplished during the baseline design/construction and is probably the most cost effective. If we locate the panelboards in one of the utility spaces and can use a surface mounted panelboard the installation can be done at any convenient time, I don't think it would be impractical to provide space for the required panelboards; you could extend the mechanical equipment room into the equipment yard to pick up the additional space. The main distribution board could be upsized to the rating required and the main circuit breaker sized for the initial load; if the charging is added the rating plug in the main circuit breaker can be replaced to support the additional capacity. The down side of sizing transformers to meet this future predicted load is we will incur system losses based on loading the transformer too lightly. I can't really comment on the practicality of electric powered vehicles but at a school like Bethke or Rice where the commuting distances are greater the demand for electric vehicle charging will probably not be there. For schools located in the more urban areas where commuting distances are shorter the electric vehicles may be more practical.

Design Challenge: Adding a Ground-Source Heat Pump (GSHP)

☐ The building design includes a GSHP system.

Show:

☑ The location of a 20,000 sq. ft. vertical bore hole field that meets the heating load of XXXXX.

☑ The location of the piping between the ground loop field and the MER.

This sheet contains the above designations: C24 - FlexEnergy Plan

Tell:

Describe how a GSHP will be integrated with your existing HVAC system and what changes will be needed in the mechanical equipment room and distribution system:

There are many options. Water-to-water heat pump units are available that can provide up to about 25-tons of capacity per unit, and can be operated in parallel to provide the building with replacement heating/cooling plant capacity that would keep the air-side HVAC system in place. Another option may be to provide a reduced-size booster biomass boiler to provide supplemental heating.

Changes needed in the occupied space (heat-pumps in the ceiling space of each rooms, etc.):

Some modifications to terminal heating elements may be required to accommodate the relatively low temperatures associated with GSHP type systems.

Design Challenge: Adding Photovoltaic Roofs

☐ The building design includes sufficient PV to provide more than 50% of the annual electrical demand.

Show:

☑ The locations of 12,500 sq. ft. of unshaded roof area suitable for PV. The annual energy demand of 320,000 kWh requires a 172kWp PV system.

This sheet contains the above designation: 3.4A - FlexEnergy Roof Plan

Tell:

Will the roof support 2 lbs per square foot on the designated areas?

Yes. Additional capacity meeting the require sq. ft. would be added as free standing cover in the parking lot or along the front walk.

How will the panels be connected to your electrical system? Where will the inverters be located? Have you added any conduit to your build-plan?

The photovoltaic system will be connected to the existing electrical system at the utility meter via a disconnect switch. This connection allows Xcel Energy to meter power generated by the photovoltaic system and put on the grid for payment to the District in accordance with approved utility tariffs. The disconnect switch allows the utility to remove all power from the meter enclosure should service of the meter be required or allows emergency responders to shut down both the utility power source and the photovoltaic source in an emergency situation. The inverters for a 172kW photovoltaic system will require construction of an additional equipment space for the equipment. Space for 10kW of inverter has been provided in the main electrical room; however there is not adequate space in the existing electrical room for the 172kW system components. Installation of the full capacity system is not possible without additional construction effort. Conduit from a 10kW photovoltaic system has been added form the roof to the main electrical room and from the main electrical room to electrical meter location. The conduit may not be adequate for the full build-out of the system. However it may be viable to parallel the existing conduits to provide additional capacity.

What aesthetic considerations have you made for adding PV? Do you think your building with PV added with be acceptable to your community?

Using a nominal value of 10 watts per square foot of collector approximately 1000 square feet of solar panels will be required for a 10kW system; the full capacity 172kW system requires 17,200 square feet of solar panels. The 1000 square feet of panel has been considered in the design of Bethke ES, the panels will be mounted on the gymnasium roof and are somewhat obscured from view by the building structure. Based on the school site it appears the installation of the photovoltaic system would be acceptable to the local community. The school site has a considerable amount of open space between the building and the property line and the nearest residences will be across a public street from the public property. The architecture and finishes of the building tend to obscure the photovoltaic panels from the immediate visual impact

Design Challenge: Adding Solar Thermal for Swimming Pool

☑ There is no swimming pool or large demand of domestic hot water in this project.

☐ A solar thermal heating system capable of providing more than 50% of the annual heating needs of the pool.

Show:

☐ The location of a 5,000 sq. ft. solar thermal system need to heat your swimming pool is 20,000 gallons, with a surface area of 2,000 sq. ft. It will require 300,000 BTU/hr heater.

This sheet contains the above designation:

Tell:

Describe how a solar thermal hot water heater will interface and inter-operate with you existing system:

Design Challenge: Adding Thermal Energy Storage

☐ A thermal energy storage system capable of storing XXX MMBTUs is part of the buildings design.

Show:

☑ The peak daily heat demand of 15 MMBTU. The default area needed to store 5 MMBTU in a Δ 30°F hot water system requires 20,000 gallons of water. At a height of 6', this requires a 24' diameter tank.

This sheet contains the above designation:

Tell:

How will the TES system be integrated into your existing design?

With the indirect evaporative cooling system, we do not anticipate the need for TES devoted to building cooling. During a summer day, the mass of the building will act as a storage medium, and the building will get warm, but not unbearably so.

On the heating side, a TES tank would need to be located to the south of the building, and connected into the existing hydronic heating system. This connection would be relatively simple, and would require a storage tank circulation pump and associated controls.

Additional comments and ideas: