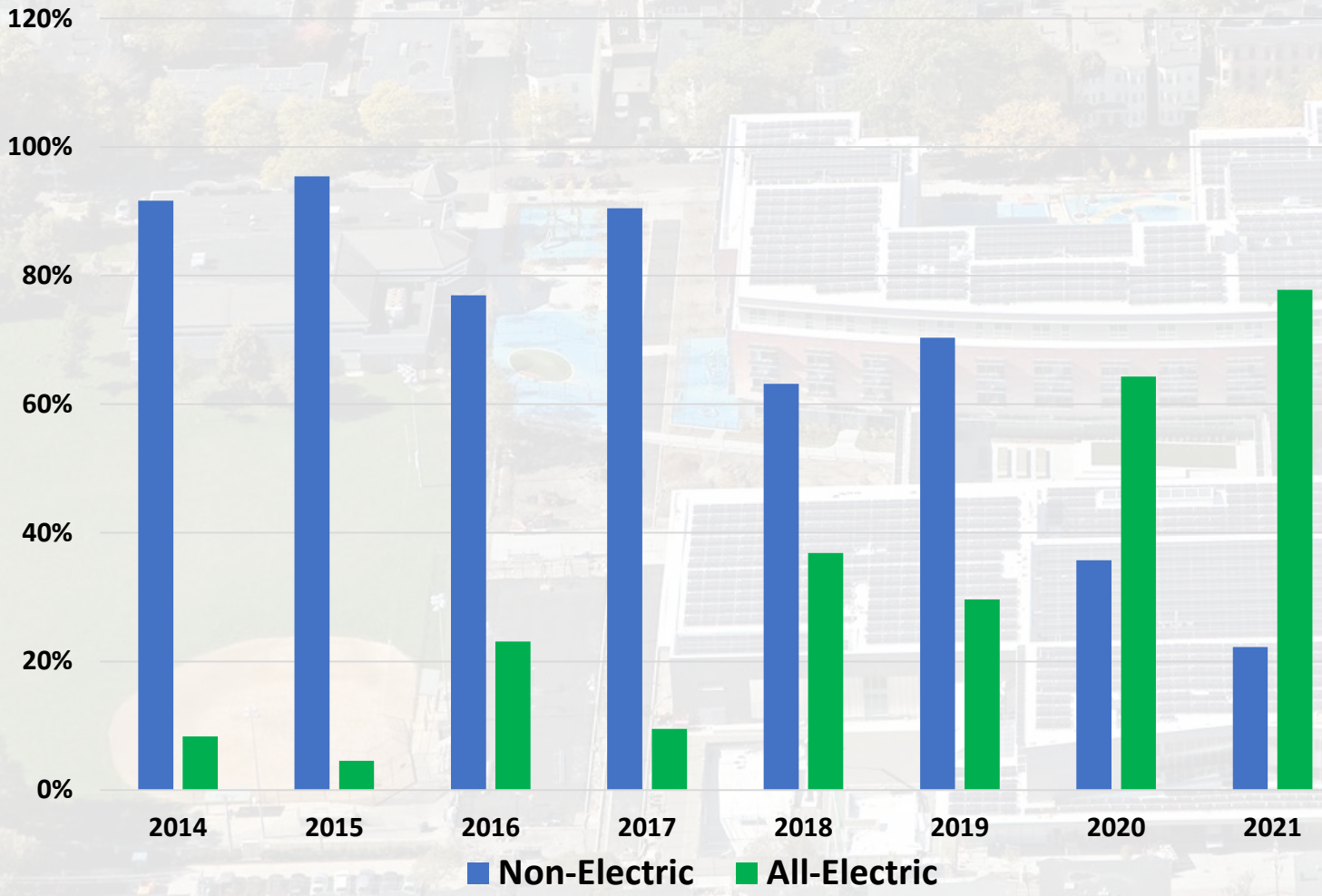
SCHOOL AND MUNICIPAL BUILDINGS

140 Projects
8-year Period



Reasons for All-Electric Trend

- Improvement in heat pump technology
  - Air source heat pump operation down to zero degrees
  - Water source heat pump providing 130-degree water at 5 degrees
- Energy Code IECC 2018/ASHRAE 90.1 2016
- EUI 25 to 35
- Efforts for decarbonization
- Rising natural gas prices

Electrical Distribution Considerations

- 50% increase in Service Size
- 100% increase in the Emergency Generator Size

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GEOTHERMAL WELL FIELD

Pros:

- High energy efficiency
- Reduced carbon footprint for environmental considerations
- Low noise levels inside and outside of building as no exterior mounted equipment with condensers or fans are required
- Potential for heat recovery; simultaneous heating and cooling

Cons:

- Increased capital investment for geothermal plant
- Requires increased site coordination for well locations
- Higher automatic temperature controls for geothermal plant equipment
- Requires increased maintenance for geothermal plant equipment (filters, additional pumps, etc.)

Options:

Traditional U-bends: HDPE (2 Pipe)

Quad Loop: Double U-Bend (4 Pipe)

Coaxial Rygan Well

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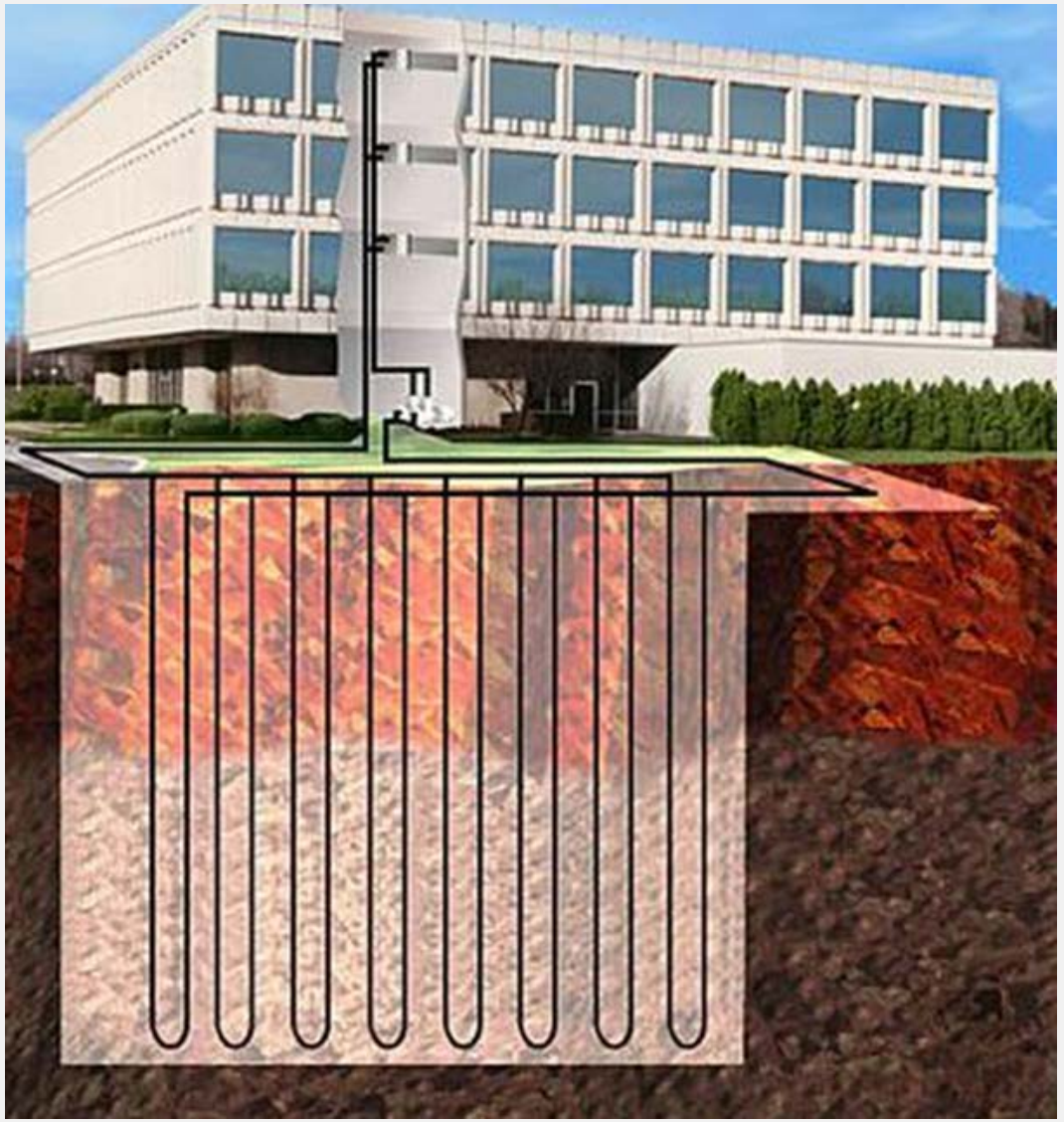
TRADITIONAL U-BENDS: HDPE (2 PIPE)

Pros:

- Easiest to install.
- 6” diameter bore required (smaller than other options)
- Installed universally by most contractors.
- Heat-exchanger available with short notice.



Cons:

- Requires more drilling than the other options provided.
- Requires the most excavation.
- Least Heat Transfer of the three heat exchangers.
  - Up to 3.25-tons per bore
  - The comparison assumes 500-foot bores
- Installed universally by most contractors.
- Heat-exchanger available with short notice.

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Pros:

- Provides up to 25% more Thermal capacity than a single u-bend
- Requires Less drilling than the traditional u-bend
- Less excavation than the traditional U-bends
- Can be installed to depths of 900-feet
- Up to 5-tons for a 600’ bore or 8-tons per 900-foot bore

Cons:

- May require a larger diameter bore than a traditional U-bends
- Limited contractors who install this heat-exchanger
- Heat exchanger requires a 4–6-week lead time to procure

QUAD LOOP: DOUBLE U-BEND HDPE (4-PIPE)

Website: www.Versaprofiles.com

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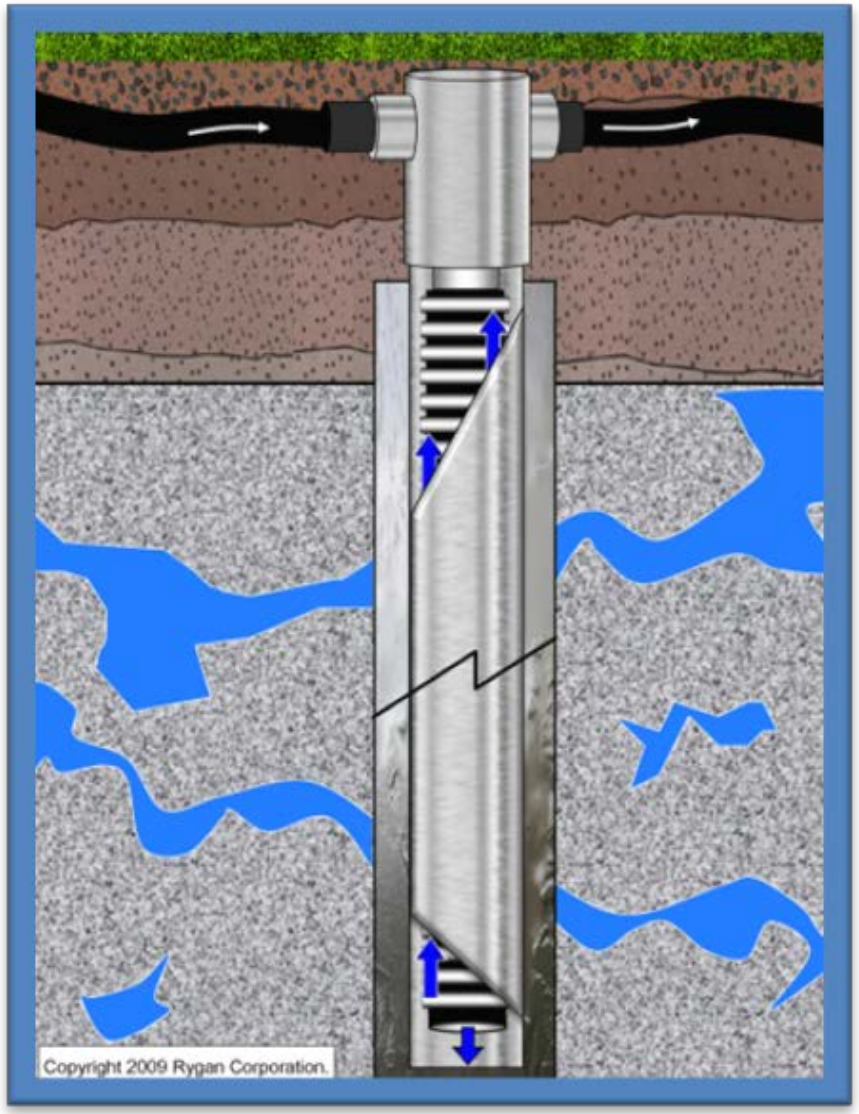
COAXIAL RYGAN WELL



The HPGX system is a coaxal heat exchanger comprised of a composite material that provides the most efficient heat transfer of the three options.

Pros:

- Requires less drilling. Fewer bores required to achieve the desired transfer.
- Less impact to the site, reduced space needed.
- Less excavation than quad & traditional
- u-bend systems.
- Can be installed to depths of 1500-feet.
- Up to 10-tons per 1000-foot bore

Cons:

- Most costly to install-per foot cost.
- May require a larger diameter bore for exchanger at deeper depths.
- Limited certified installers
- Long lead times to procure product

Website: www.Rygancorp.com

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MECHANICAL SYSTEM PAYBACK SUMMARY

SCHOOL EXAMPLE

Baseline	System	Gross Capital Investment*	Annual Elec. Cons. (kWh)	Annual Gas Cons. (MBTU)	Annual Electric Cost	Annual Gas Cost	Combined Utility Cost	Annual Utility $/s.f.	Annual kBTU/s.f. (EUI)	Annual Maint. Cost	20 Year Exterior Equipment Replacement Cost	Combined Annual Expense	Combined Expense Savings**	Total Life-Cycle Savings***	Discounted Payback (Years)****
Code Baseline	1. Hot water coil heating/chilled water coil cooling VAV AHU system with energy recovery and terminal VAV boxes with hot water reheat coils 2. Code-efficient gas-fired non-condensing boiler plant 3. High-efficiency (code) water-cooled chiller plant with cooling tower	$7,065,144	542,150	1,784.8	$108,430	$22,489	$130,919	$1.16	32.1	$132,704	$1,469,500	$263,623	-	-	-

Option	System	Gross Capital Investment*	Annual Elec. Cons. (kWh)	Annual Gas Cons. (MBTU)	Annual Electric Cost	Annual Gas Cost	Combined Utility Cost	Annual Utility $/s.f.	Annual kBTU/s.f. (EUI)	Annual Maint. Cost	20 Year Exterior Equipment Replacement Cost	Combined Annual Expense	Combined Expense Savings**	Total Life-Cycle Savings***	Discounted Payback (Years)****
Base Design	1. Dehumidification displacement ventilation diffusers with radiant heating panels 2. Gas-fired heating/dx cooling VAV ventilating units with energy recovery with terminal VAV boxes with CO2 controls 3. High efficiency gas-fired condensing boiler plant	$6,026,583	511,760	1,561.7	$102,353	$19,678	$122,031	$1.08	29.2	$130,279	$919,850	$252,310	$11,313	$1,856,606	Instant ******
Tier 1	1. Dehumidification displacement ventilation diffusers with radiant heating panels 2. Hot water coil heating/chilled water cooling VAV ventilating units with energy recovery with terminal VAV boxes with CO2 controls 3. High efficiency water-cooled chiller plant with dry cooler 4. Supplemental electric boiler plant	$7,666,934	887,380	0.0	$175,476	$0	$175,476	$1.55	26.8	$122,079	$330,000	$297,555	-$33,932	-$685,229	Not Reached *****
Tier 2	1. Dehumidification displacement diffusers with radiant heating panels 2. Hot water coil heating/chilled water cooling VAV ventilating units with energy recovery with terminal VAV boxes with CO2 controls 3. Geothermal wells with high-efficiency water-to-water source heat pump chillers	$10,917,434	667,000	0.0	$133,400	$0	$133,400	$1.18	20.1	$121,079	$0	$254,479	$9,144	-$2,307,572	Not Reached *****
Tier 3	1. Dehumidification displacement diffusers with radiant heating panels 2. Hot water coil heating/chilled water cooling VAV ventilating units with energy recovery with terminal VAV boxes with CO2 controls 3. Geothermal wells with high-efficiency water-to-water source heat pump chillers 4. Supplemental electric boiler plant	$10,459,048	754,620	0.0	$150,923	$0	$150,923	$1.33	22.8	$122,079	$0	$273,002	-$9,379	-$2,396,360	Not Reached *****

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MECHANICAL SYSTEM PAYBACK SUMMARY

SCHOOL EXAMPLE

Baseline	System	Gross Capital Investment*	Annual Elec. Cons. (kWh)	Annual Electric Cost	Annual Utility $/s.f.	Annual kBTU/s.f. (EUI)	Annual CO2 Emissions (kg)	Annual CO2 Emissions Reduction (kg)	Annual Maint. Cost	Combined Annual Expense	Combined Expense Savings**	Total Life-Cycle Savings***	Discounted Payback (Years)****	LEED EAc2 Points
-	1. Electric heating/chilled water cooling VAV air handling units with energy recovery wheels with terminal fan-powered VAV boxes with electric reheat coils 2. High efficiency (code) water-cooled chiller plant with cooling tower	$9,701,980	1,423,400	$224,748	$1.45	31.3	876,598.8	-	$32,125	$256,873	-	-	-	-

Option	System	Gross Capital Investment*	Annual Elec. Cons. (kWh)	Annual Electric Cost	Annual Utility $/s.f.	Annual kBTU/s.f. (EUI)	Annual CO2 Emissions (kg)	Annual CO2 Emissions Reduction (kg)	Annual Maint. Cost	Combined Annual Expense	Combined Expense Savings**	Total Life-Cycle Savings***	Discounted Payback (Years)****	LEED EAc2 Points
1	1. Full air-conditioning displacement ventilation diffusers with passive heating radiation 2. Hot water coil heating/chilled water cooling VAV air handling units with energy recovery with terminal VAV boxes with CO2 controls providing displacement ventilation 3. High efficiency water-to-water source heat pump chiller plant with fluid cooler 4. Supplemental electric hot water boiler plant	$7,818,915	1,122,100	$177,176	$1.14	24.7	690,980.5	185,618.3	$23,150	$200,326	$56,547	$3,182,845	Instant*****	14
2	1. Variable refrigerant flow (VRF) terminal evaporator units with air-cooled condensing units serving the administration, classroom media center, and support areas 2. Split system air-cooled heat pump heating/cooling VAV dedicated outside air handling units with energy recovery with terminal VAV boxes with CO2 controls providing ventilation to the VRF units 3. Full air-conditioning displacement ventilation diffusers with passive heating radiation 4. Split system air-cooled heat pump heating/cooling VAV air handling units with energy recovery with terminal VAV boxes with CO2 controls providing displacement ventilation to the dining, gymnasium, multi-purpose/stage, and small gymnasium areas	$8,334,430	1,222,000	$192,959	$1.24	26.9	752,498.2	124,100.6	$50,750	$243,709	$13,164	$1,744,635	Instant*****	12
3	1. Full air-conditioning displacement ventilation diffusers with passive heating radiation 2. Hot water coil heating/chilled water cooling VAV air handling units with Tempeff energy recovery with terminal VAV boxes with CO2 controls providing displacement ventilation 3. High efficiency water-to-water source heat pump chiller plant with closed-loop geothermal wells	$10,044,815	949,250	$149,887	$0.97	20.9	593,291.3	283,307.6	$18,150	$168,037	$88,836	$1,922,366	5	16
4	1. Hot water heating/chilled water cooling coil VAV air handling units with energy recovery wheels with terminal fan-powered VAV boxes with hot water reheat coils 2. High efficiency (code) water-cooled chiller plant with cooling tower 3. Electric hot water boiler plant	$9,745,335	1,435,000	$226,588	$1.46	31.6	883,662.0	-7,063.1	$33,125	$259,713	-$2,840	-$107,059	N/A******	7

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