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Energy Terms
A Confusing Mix – Even for Engineers!

Electrical Energy: Amps (current), Volts (electrical potential), Kilowatts (energy), Kilowatt-hours (power), Demand (max. energy draw in a 15 minute period)

Air Conditioning: Tons (equivalent cooling capacity of one ton of ice)

Heating: BTU/hr (British Thermal Unit per hour)

Insulation: R-Value (how resistant insulation is to the conduction of heat energy)

Heating Degree-day: HDD (a measure of how much heating energy is required on a specific day, using 65 degrees as the baseline) Eg: If the average temperature throughout a day was 60 degrees, it would represent 5 HDDs.

Cooling Degree-day: CDD (same, but for cooling energy). Eg: If the average temperature throughout a day was 85 degrees, it would represent 20 CDDs.

Delta-T: Short-hand term for the difference in temperature between two objects or locations.

MERV: "Minimum Efficiency Reporting Value" for air filters (high numbers are finer filtration).

Natural Circulation: The transfer of energy due to mass flow, resulting from natural temperature differences. Eg: Why it is warmer near the ceiling, than at the floor, making ceiling fans helpful.

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Engineering Basics

What are the modes of heat transfer?

Conduction: Transfer of heat without movement of the material.

- Requires physical contact. Eg: Do not touch a hot stove!
- Different materials have different effectiveness of heat transfer. Think of copper vs/ styrofoam.
- Proportional to temperature difference (Delta-T).

Convection: Transfer of heat in a fluid (liquid or gas).

- Mass transfer within the fluid medium. Eg: Drying your hair with a hot air blower.
- Liquid transfer much more efficient than gas. Eg: Water feels colder than air.
- Proportional to Delta-T.

Radiation: Transfer of heat by infrared radiation.

- Requires no medium: solid, liquid, or gas. Eg: How the Sun heats the Earth in the vacuum of space.
- Dominant at very, very high temperatures (proportional to T^4). Eg: Surface of Sun is 10,000 degrees!
- Negligible at normal room temperature. So … Don't pay for radiant energy insulation (not cost effective in the home).

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Examples in Our Buildings

Conduction:

- Energy transfer through a wall, a window, or a door.
- Energy transfer to the earth through the floor.
- Energy transfer to attic and to atmosphere through the ceiling and roof.

Convection:

- Air transfer through Heating, Ventilation, and Air Conditioning (HVAC) system (forced air system).
  - Systems required to have minimum 10-20% flow from outside for ventilation of indoor spaces. So do not run your house fan continuously.
- Air leakage through door and windows (drafts).
- Natural circulation flow of air within a room (hot air rises). Ceiling fans help equalize temps.
- Transfer of heat from attic to atmosphere (it is always hot up there).

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How do we condition our air?

Heating in Winter

- Gas furnace using forced air (typical of this area).
- Heat pump: Uses electricity and closed working fluid to transfer energy from outside to inside (uses electricity, vice carbon-based fuel, reducing carbon pollution).
- Fuel oil, hot water, or forced air furnace (still used in East).

Cooling in Summer

- Air Conditioner: Uses electricity and a closed working fluid to transfer energy from inside to outside.
- Evaporative Cooler: Uses hot air flow through a water-soaked filter to cool the air. Uses very little energy and adds humidification. Great in our area of low humidity. Does not work in areas of high humidity.
- "Whole house" ventilation: Uses night-time temperatures to cool house. Can be operated automatically and uses very little energy.

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How do we control conditioning of our air?

- **Basic Thermostat – adequate for a full-time residence, non-working family.**
  - Conditions air to a "Set-point" temperature, which is adjusted manually.
  - Must manually transfer from heating to cooling.
  - Can turn fan on or set to automatic operation.
- **Programmable Thermostat – needed if building is unoccupied for significant time periods. Saves energy cost by reducing temperature difference, compared to outside air.**
  - Allows automatically adjusted set-point temperatures, based on building usage schedule.
  - Automatically shifts from heating to cooling, as required.
  - May be operated remotely.
- **Building Management System – needed when managing multiple zones and equipment.**
  - Allows remote reprogramming. I do this each week for GSPC.
  - Records actual temperature and humidity data, allowing troubleshooting.
  - Reduces electrical demand charges due to multiple units operating simultaneously.

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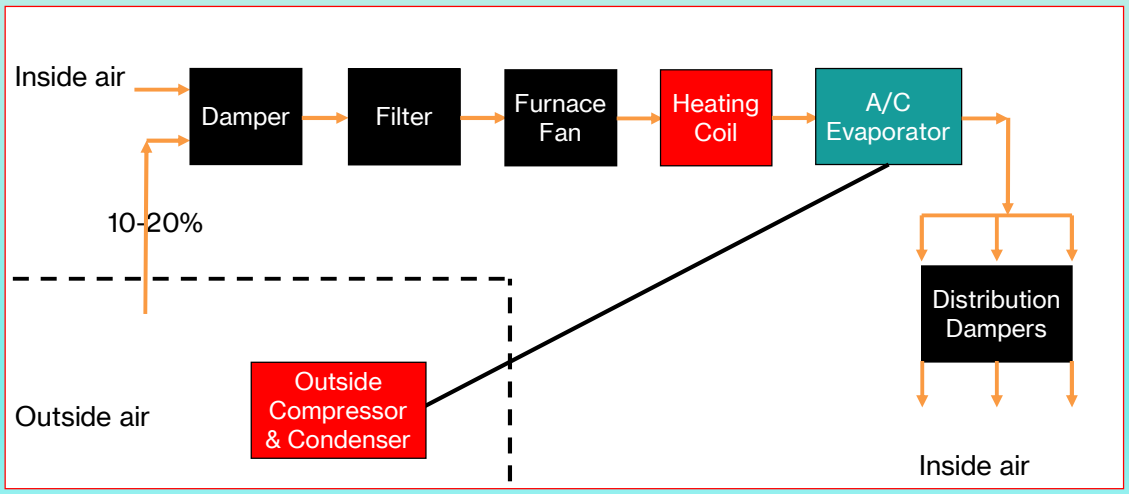
Typical Air Conditioning System



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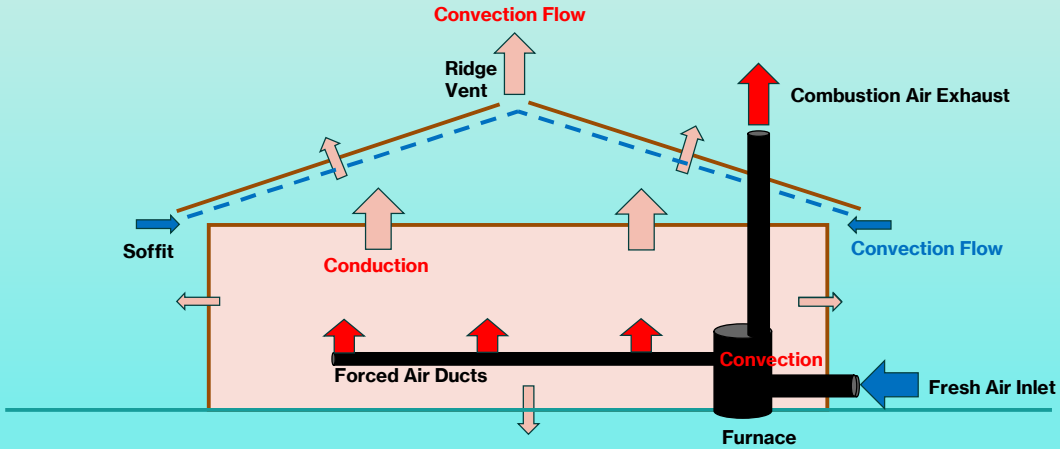
Typical Energy Pathways in Your Home



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HVAC Maintenance

Homeowner Maintenance:

- Filter changeout (2 x yearly): Recommend MERV-7 or 8 for normal household filtration. Recommend MERV-13 (high efficiency filter) for allergenic considerations.
- Adjust dampers: Start with all dampers wide open. Cut back individual dampers in steps for areas that are over-conditioned (too hot if heating, or too cold if cooling). Allow one day between adjustments.
- Check heat/cooling effect at start of each season: Use an inexpensive, infrared thermometer, comparing inlet air temperature with outlet damper air temperature. Typically, 16-22 degrees F difference for A/C. Typically, 40-70 degrees F difference for gas furnace; lower for heat-pump.

HVAC Professional:

- Annual air conditioning check at start of summer season.
- Annual furnace check at start of winter season.
- Replace starting capacitors, if measured outside of nominal range. These components are inexpensive and cause the most frequent unplanned failures of your heating/cooling system.

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GSPC's Journey to Energy Efficiency

2017: Self-Assessment of Overall HVAC System

- Checked age, capacity, and Delta-T of all furnaces: Total of 9 furnaces, 3 of which are twinned units.
- Checked age, capacity, Delta-T, and operating currents on all A/C units: Total of 7 A/C units, 2 of which used old working fluid (which was very expensive) and leaked. Main unit for CEB was operating above rated electrical current.
- Checked Energy Use/Cost: Fully ½ of our energy use went to A/C in summer. Electrical demand charges were 1/3rd of our cost for electricity. When multiple A/C units operated simultaneously, GSPC exceeded its allowable electrical demand (City threatened changing our customer category, which would raise cost).
- Inspected Attics: Attic insulation was below standard levels (minimum R-value of 30, preferred 50). In some cases (Sanctuary) had next to no insulation installed during construction. Found three duct hoses in attics that had disconnected.
- Attic ventilation was inadequate due to blocked natural circulation. Building expansion blocked attic ventilation in CH. Initial construction of CEB installed ridge vent, but no soffit vents. Soffit vents in Narthex were all clogged with blown-in insulation.
- Inspected all exterior doors/windows: All windows were double insulated, but several showed defects in the seals.
- Checked lighting: All lights had already been upgraded to LED.

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GSPC's Journey to Energy Efficiency

2017: Professional Energy Audit

- Requested and obtained **Therm-Wise Energy Audit** from gas company. Commercial electric companies will also typically offer free audits. City energy companies do not.
  - Professional inspections and consultations.
  - Measured duct leakage: Found to be excessive.
  - Inspected exterior with thermal camera: Only noted minor leakage around a few windows/doors.
  - Formalized in a written report, with specific recommendations.
  - Offered rebates on cost of duct sealing and attic insulation.

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GSPC's Journey to Energy Efficiency

2017: Building Committee Prioritized Needs and Session Approved Budget

2018: High Priority Actions

- Duct sealing of all attic ducting.
- Insulating all attic spaces to R-45. Cleared all soffits.
- Added attic roof vents (high and low, as appropriate) to achieve 1 to 30 ratio.
- Installed Smart thermostats (programmable and lockable) and purchased Building Management Program.
  - Learned that all HVAC units significantly exceeded actual needed capacity

2019: Replaced both CEB HVAC units

- Eliminated both units which leaked and used out-dated working fluid
- Removed CH second unit and re-used in CEB Main Hall. New unit for Office Area.

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GSPC's Journey to Energy Efficiency

2020 (COVID period) Added ability to purge air in Sanctuary between Sundays + future potential for night-time cooling of the Sanctuary.

- Installed purge valve in Sanctuary/Narthex system
- Installed HEPA filters in Sanctuary system.

2023-2024 Reassessment performed by B&G Committee/ Bequest available.

- Replace all windows in CEB with Energy Star rated.
- Installed Solar Electric System
  - Rated to produce full GSPC electrical usage/year.
  - Capable of 33% expansion, if required in future.
  - 30% savings on installation cost from Federal Gov.

Future: Continue Journey to Achieve Net-Zero Carbon Footprint.

- Replace 6 remaining A/C units with Heat-Pumps, as fail. Down-size A/C unit capacity on replacement. Retain gas furnaces, as backup only.
- Replace 2 gas-hot water heaters with electric, as fail.
- Add Solar Electric arrays, if required, to maintain full annual electric capacity.

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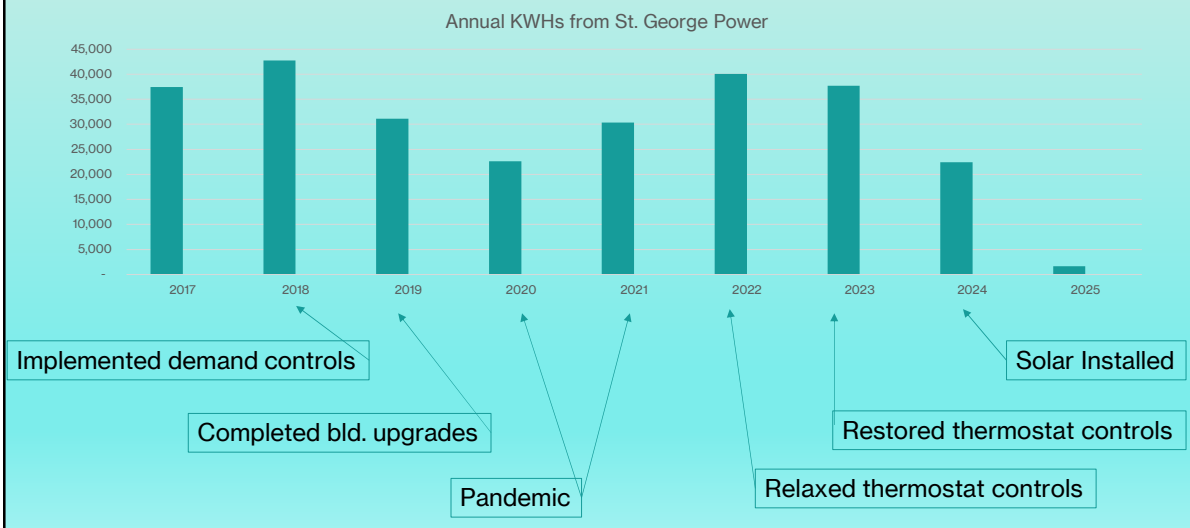
GSPC's Journey to Energy Efficiency



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Pictures of Attic Insulation in Sanctuary

Before

After

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Pictures of Duct Sealing

Unsealed Duct (before)

Sealed Duct (after)

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Duct Physically Separated in Attic

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Solar Electric System

Sufficient power to offset GSPC's annual electrical energy use (38,000 KWHs).

Capability for cost-effective expansion in the future (up to 33% more power).

Installation which does not detract from the visual appeal of the Church.

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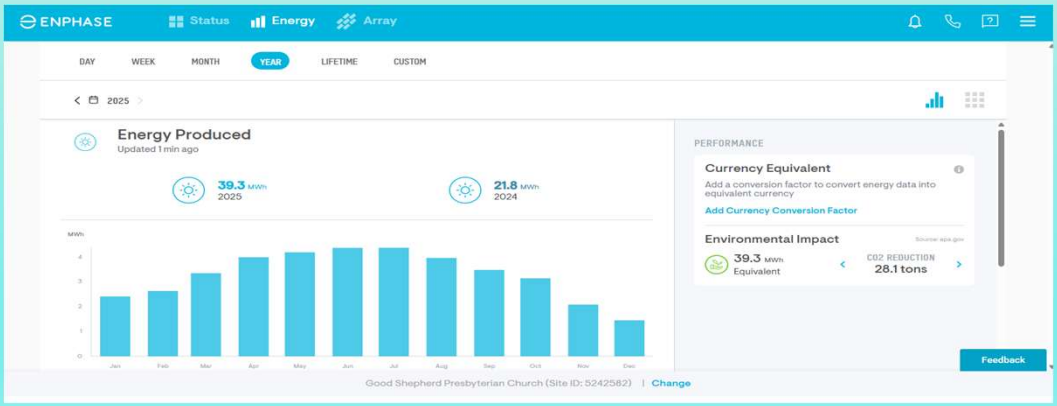
Solar Electric Energy Produced in 2025

We produced more energy than we used. We saved $2,500 on our electricity bill.



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How GSPC's Journey Can Be Used at Your House

Know the General Principles that guide Energy Efficiency.

Know your energy usage history for the past 5 years. Identify trends and peak periods.

Inspect your Attic Areas for insulation (R-30 = 9 inches; R-50 = 15 inches). This is for blown-in insulation, which is predominant in our area.

Inspect your Attic and Roof for adequate ventilation, both high and low vents (both are required for natural circulation). Ensure insulation does not block the vents.

Request a free Energy Audit (if available) from your local utility provider.

Perform periodic self-checks and maintenance on your HVAC unit.

Perform annual professional checks on your AC unit and Furnace.

Based on your inspections and audits, develop and budget for energy efficiency upgrades prioritized based on "biggest return on investment". Take advantage of rebates from utility company and manufacturers.

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Other Hints

Use Whole House Ventilation to delay energy-expensive conditioning of your rooms in Spring & Autumn.

Consider use of Evaporative Coolers in certain areas of your home (eg: Garage, Patio Room).

Many companies in the Energy business will offer free inspections. But beware: They have a vested interest in selling THEIR product.

Get competitive bids from multiple suppliers against a written "Scope of Work". You learn a lot by just talking to their representatives as they prepare your bid. But remember, sometimes you get what you pay for; so, it may not be wise to go with the low bidder. Trust your instinct.

Get recommendations from your neighbors.

And … I am happy to help you get started:

Guy Schultzman, retired Engineer

GBSchultzman@Yahoo.com or 435-705-9239

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GSPC's Journey to Energy Efficiency

And God so loved the World, that He gave His only begotten Son …

As Christians, we have a sacred duty to protect His creation.

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