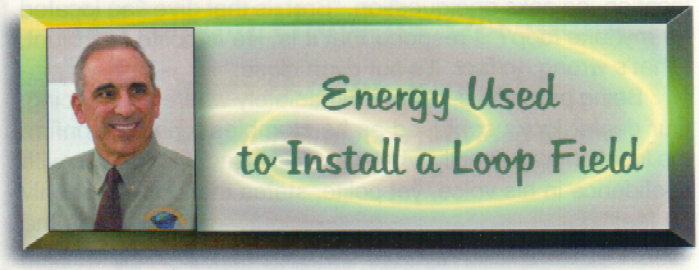

Energy Used to Install a Loop Field

by Peter Tavino PE, CGD

The latest issue of *Strategic Planning for Energy and the Environment* has an important article by D. Wulfinghoff entitled: "Where Energy Efficiency and Alternative Energy Work, Where They Don't, and Why." The first of ten questions he asks is: What is the Energy Return Ratio (ERR) of the project?

ERR = Energy Output ÷ Energy Input
(to manufacture, install, and maintain)

An oil extraction project with ERR of 4:1 requires one barrel of oil to produce four barrels, netting three to use. Controlled by physics, low ERR projects should be avoided. Decision makers use Return On Investment (ROI) to determine project cost versus savings, but if ERR is very low, long-term ROI must be distorted by subsidy to make it feasible.

A geothermal ground source heating and cooling project will be compared to other energy projects cited with the approximate values shown in the chart below.

Project	ERR
Solar Collector Space Heating	1 : 1
Photovoltaic Power	1 : 1
Corn Ethanol	1.4 : 1
Wind Farm	3 : 1
Nuclear Power	4 : 1
LED Replacement Lights	6 : 1
Coal Generating Electricity	6.2 : 1
Hydroelectric Power	10 : 1
Efficient Residential Design	10 : 1
Oil/Gas Production today	10 : 1
Oil/ Gas Production 50 years ago	100 : 1

Geothermal was not included, so where does ground source fit in? What is the energy input needed to install a vertically-bored closed-loop field?

We recently drilled a 30-ton* system with 9 bores at 450 feet*, 8 deep in solid schist having thermal conductivity of 1.75, 1.0 grout surrounding 1¼-inch* U-bends with 720 feet* of 2-inch* reverse return home runs to the library building.

The energy needed to manufacture the high-density polyethylene (HDPE), bentonite, silica, and propylene glycol is added to the energy for the 6-inch* drilling, 35-foot* average steel casing, and excavating. Consistent units of million British thermal units (MMBtu) are used. **Total = 322 + 194 = 516 million Btu to install the loop field.**

Work Description	Units	Formula	MMBtu
Drill 6" dia. boreholes	4050 feet	6 days x 9 hrs @ 25 gallons diesel per hour = 1350 @ 140,000 Btu/gal	189
Service truck @10% fuel		189 x 0.10	19
Grout rig	4050 feet	3 days x 8 hrs @ 10 gal/hr = 240 x 140,000 Btu/gal	34
Trackhoe excavator	groundwater control + 200 feet of trench	3 days x 8 hrs @ 8 gal/hr = 192 x 140,000 Btu/gal	27
Power for fusion, casing torch, coring, & air purge	1 + 5 + 2 + 4 kilowatt-hours	12 @ 3412 Btu/kWhr	1
Workers to, from, & on-site	4 workers @ 12 days	48 trips @2 gal x 1.5 on-site = 144 @ 140,000 Btu/gal	20
Trucks & excavator maintenance & depreciation	10% of usage	(189 + 19 + 34 + 27) x 0.10	27
Drill bits, equipment	2% of usage	269 x 0.02	5
Subtotal			**322**

Of course, the loop field is dependent on the heat pump operation inside the building. At average efficiency of 3.0, this will use 742.5 ÷ 3 = 248 MMBtu/year.

Add in the energy to install the heat pump, circulator, and distribution system. Assume 2 times the energy to make the heat pump and install the entire system (in line with cost ratio 2:1 HVAC work versus borehole work) = 2 x 516 = 1032.

For the 20-year life of today's heat pump and 50 or more years for loop: Input Energy = (516 x 20 ÷ 50) + (1032) + (20 x 248) = 206 + 1032 + 4960 = 6198 MMBtu.

Building analysis software shows for the Connecticut climate, heating load is 449.1 MMBtu per year, and cooling load is 293.4 MMBtu annually = 742.5 total.

Output Energy = 742.5 per year x 20 years = 14,850 MMBtu.

Materials Description	Units	Formula	MMBtu
High-density poly pipe	9000 feet	0.312 lbs/ft 1¼" & 0.639 lbs/ft 2" =3043@1.75 lbs petroleum per lb HDPE x19,000 Btu/lb	101
6" Steel casing	315 feet Sched. 80	28.57 lbs/ft x 315= 9000 lbs @ 12.6 MMBtu/ton shipped	57
Bentonite	20 bags/hole	9 x 20 x 50 lbs =9000 lbs @ ½ cement, 2.3 MMBtu/ton	10
Silica	5 x bentonite	45,000 @ 40% bentonite	4
Local sand bedding	60 tons	60 ÷ 45 = 1.33 x 4	5
Clean water	784 gallons in loop x 5 to drill	Estimate 1	1
2 Drums propylene glycol	110 gallons	Estimate 1 each	2
Transport to site	500 miles x 2 loads shared	1000 ÷ 10 miles/gal @ 140,000 Btu/gal	14
Maintenance of loop			0
Subtotal			**194**

Therefore, ground source ERR = 14,850 ÷ 6198 = 2.4, is feasible where solar isn't, better than wind when transmission is added, and competitive with disappearing 10:1 fossil fuels, which reduce to the 2.4 range when we account for delivery, storage, boiler, furnace, radiator, and air handler energies. The loop field itself takes 516 ÷ 742.5 = 0.7 x 12 = only 8 months of a building's energy use to install permanently. Investments in properly-constructed geothermal projects, and subsidies, paid back with worker income tax, are clearly prudent.

*(1 ton ≈ .907 tonnes) (1 foot ≈ .304 meters)
(1 inch ≈ 2.54 centimeters)

Peter

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